71 8

BULLETIN
OF THE
NANSEI REGIONAL FISHERIES RESEARCH LABORATORY

No. 8

南西海区水産研究所研究報告

第 8 号

昭和 50 年 10 月
南西海区水産研究所
広 島
NANSEI REGIONAL FISHERIES RESEARCH LABORATORY
FISHERIES AGENCY
HIROSHIMA, JAPAN
October, 1975

目　次

Bull. Nansei Reg. Fish. Res. Lab. (8) 1～10 (1975)

海産底棲魚類に寄生する線虫に関する研究－Ⅱ.

仔虫の発育経過および第1中間宿主への人工感染

阪 口 清 次・福 原 修

Studies on a Nematode, *Philometra*, in the Marine Benthic Fishes-II.

Morphology of the Larvae and Experimental Infection to the Intermediate Host.

Seiji SAKAGUCHI and Osamu FUKUHARA

Summary

Some observations of embryonic development in the uterus of female worm and experimental infection with the larvae to the first intermediate host were carried out on the Nematode, *Philometra mariae*, parasitic to the marine benthic fishes, *Rhinogobius pflaumi* and *Chaeturicys sciitius*. The results are summarized as follows:

1. The embryos developed in the uterus of female and grew completely to the active first-stage larvae in the uterus of female from August to September. The larvae escape into the seawater after rupture of the body of the gravid worm which is living in the capsule being formed in the subcutaneous tissue of the host fish. Each gravid worm of 8-20 mm in length contains 20,000-100,000 larvae in the uterus.
2. Some copepode presumed as first intermediate host were experimentally exposed to the first-stage which were kept in a small vessel. The larvae were successfully obtained from the hemacoel of the infected copepods of several species. The larvae ingested by the copepod, penetrate into the hemacoel through the gut wall and then they develop to the third-stage larva after two times molt in the place.
3. The free living larvae kept in the seawater at 20°C of water temperature showed high survival rates for 4 days, but thereafter the mortality is increased pari passu with days. They possessed the ability to penetrate into the host for 3 days.
4. Larval development of the *Philometra* in the uterus of gravid worm and in the hemacoel of copepod are following:
   1) The first-stage larvae just escaped from the gravid worm are unsheathed and 360-460 μ in the length and 14-15 μ in width. The larvae are characterized by long filiform tail, tapering to a sharp point. Three lips are visible on the top of anteror extremity of the body. The esophagus appears narrow muscular, hogeneous tube and protrudes into the lumen of the intestine which is not yet joined to the proctodeum in the stage. The anus is situated at the ventral surface a distance of 85-95 μ from the posterior end. The intestine of the first-stage larva, is joined with the rectum after developed for 2 days in the hemacoel of the copepod. They move actively in the hemocoel of the copepod.
   2) The second-stage larvae were found in the copepods after 5 days. These larvae have

1975年5月29日受理　南西海区水産研究所業績46号

a loose sheath. They did not move actively in the hemocoel of the copepod. The tail of the second-stage larva is shorter and rapidly tapers to a sharp point. The esophagus is divided into a relatively narrow muscular part and thicker glandular portion.

3) The third-stage larvae were found in the copepods maintained in the seawater of 20℃, during 25 days. The third-stage larva differs from the second-stage in the following points:

The muscular bulbous part comes to be discenible at the anterior port of musular esophagus. The glandular portion of esophagus is width and the structure of the esophagointestinal valve is protruded into the lumen of intestine.

前報では，広島湾北西域の海産底棲魚類に寄生する線虫について，宿主における寄生生態および成虫の形態などを検討して，本種を *Philometra mariae* と同定した[1]。

魚類から得られた本属線虫については多くの記載があるが[2)3)]，生態についの報告は少なく，とくに生活史に関して，感染実験が試みられているのはいずれも淡水産種のみである[4)5)6)]。

著者らはこの海産線虫の生態を明らかにするために，スジハゼに寄生する線虫を材料として研究を進めた。すなわち，宿主の表皮下に寄生している雌虫の子宮内仔虫の発育経過とその形態を観察し，あわせて，発育した第1期幼生を第1中間宿主と想定される小型甲殼類へ人工感染させた。この結果，2，3の橈脚類で感染に成功し，2回の脱皮を経て感染仔虫として発育させることができたので，その経過および寄生生態などについて報告する。

稿を草するにあたり，指導と校閲を賜わった保科利一博士ならびに淡水区水産研究所水質病理部長藤谷超博士に深謝する。また，実験材料の採取については南西水研・山口義昭，後藤幹夫技官に一方ならない御協力をいただいた。心から感謝の意を表する。

Ⅰ．母虫の子宮内における仔虫の発育および産仔現象

材料および方法

供試材料は1972年9月～10月および1973年7月～10月までに，広島湾北西海域の山口県岩国市から広島県大竹市に至る沿岸域で手繰第2種漁業のエビ漕網で採集したスジハゼのうちで，表皮下に包嚢の形成している罹病魚から得られた雌虫である。実験に当っては，罹病魚を生かしたまま運搬し，屋内のガラス水槽に飼育しておき，適宜とりだし母虫の子宮内仔虫の発育状態を観察した。

虫体の観察は主として生標本について行なったが，必要に応じて10%ホルマリン液で固定したものをラクトフェノールで透化させ検境した。虫体の諸器官の大きさは生きた標本の両端に厚さ0.2㎜のカバーグラスの細片をおき，その上に静かにカバーグラスをのせマッチの焔で軽くスライドグラスの下から温め，仔虫の運動を弱めて計測した。

結　果

1　子宮内仔虫の発育とその形態

宿主の表皮下に包嚢を形成する以前の6～7月ごろの雌虫は，鰓表ならびに胸鰭屈筋中などにしばしばみられるが，これらの母虫の子宮内には球形を呈する卵が充満している。母虫が宿主の表皮下に出現して包嚢を形成する8月ごろになると，子宮内には各発育段階の胚がみられるようになり，8月から9月ごろになると活発に運動する仔虫によって子宮内は充たされる。初期の受精卵は直径約20μの球形であるが，定則どおり，卵割が進み，桑実期，胞胚期および嚢胚期を経て胚子を形成する。胚子は伸長するにつれて，その皮下に液胞を生じ，ついでこれが崩壊することによって卵膜がゆるみ，ゆるやかに螺旋運動をするようになる。胚子は卵膜中でコイル状を呈して次第に成長し，体長270～300μになると孵化し，活発に運動する仔虫となる（Fig. 1)。発育した第1期仔虫は全体としては糸状を呈するがその他鎌状あるいは環状に巻曲してみられ

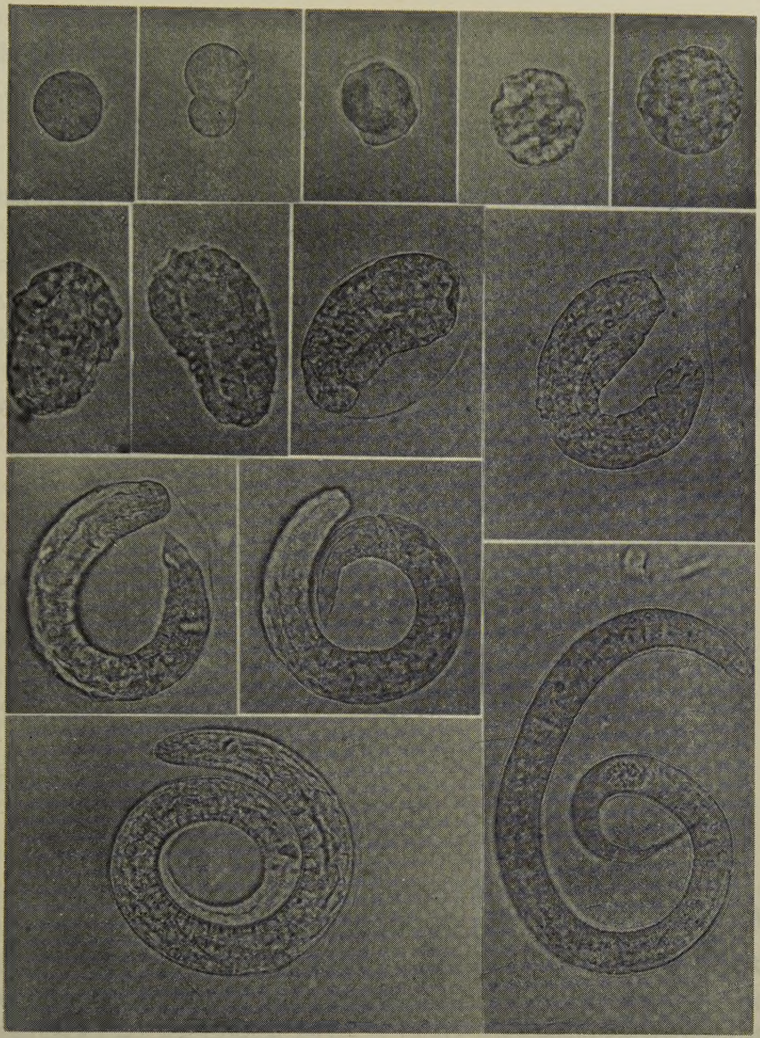


Fig. 1. Development of *Philametra mariae* in the uterus of female.

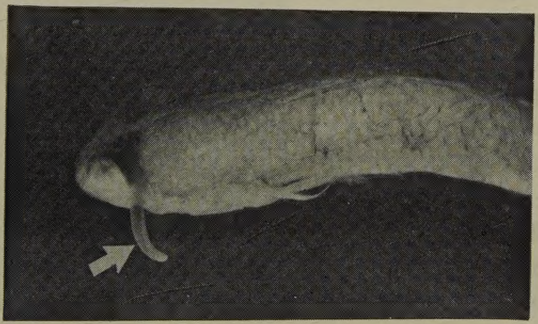


Fig. 2. A gravid worm emerged from the capusule in supcutaneous tissue of the operculum of the host fish.

る。大きさは体長360～440μ，体幅14～15μである。尾部は細長く，かつ尖っている。頭端には未発達の三叉した口唇がみられる。食道は細長く110～160μを算し，未発達の同質同型の筋肉性の管状を呈し，その末端は腸内に連結している。腸の長さは120～160μで体腔内を後方に向って直走するが，後腸とは結合していない。後腸は盲管をもたない単純な管状で，体の後方から85～95μに位置する肛門に開く。

2　母虫の脱出現象ならびに産仔数

宿主の体表から産仔中の母虫は，体の前端部を皮下組織中に留め，円筒状の体部を海中に露出させて宿主の游泳にともなって軟泥状の仔虫塊を盛んに放出する。宿主を麻酔させ計測したところ，虫体の露出部の長さは12㎜，皮下組織内には0.4㎜の頭部を残存させていた。露出部の検鏡観察では母虫の体壁は裂開して腸管と子宮を体外に脱出させ，その先端は擦り切れ，断端が開口しているため子宮内の仔虫はほとんど完全に流出していた（Fig. 2.)。子宮内仔虫の概数を把握するため，10月採集の罹病魚から体長の異なる母虫6個体を選び，子宮内の仔虫数を稀釈法により計数盤を使用して顕微鏡下で数えた。反復5回の資料から母虫1体の産仔数を推定した結果は Table 1. のとおりであり，母虫の体長に対応して2万～10万程度の仔虫を抱含していた。

Table 1. Numbers of larvae by size observed in the uterus of gravid worm

Numbers of larva $(\times 10)^3$	Total length of worn (mm)
20.9 ± 1.9	8.0
32.0 ± 1.6	11.5
35.1 ± 1.4	13.0
63.2 ± 4.0	14.0
71.5 ± 2.5	16.5
109.3 ± 6.8	20.0

Ⅱ．仔虫の第1中間宿主への人工感染

材料および方法

人工感染実験は仔虫が充分発育していることを確めたうえで実施した。第1中間宿主の探索のために供試した小型甲殻類は南西水研地先の海域でネット採集した。さらに屋外のコンクリート水槽の壁面に付着していた小型甲殻類も採集して実験に供した。これらは天然に由来する線虫の感染のないことを確認した。1972年の実験によって第1中間宿主が，2，3の橈脚類であることが明らかになってからは，寄生生態を主体として研究するために，宿主としては人工培養したチグリオパス*Tigriopus japonicus*をもっぱら利用した。

虫体の観察および諸器官の大きさの測定は前項と同様な方法によった。

結　果

1　第1中間宿主の探索

1972年10月13日に採集した罹病魚から得た母虫5尾の子宮内から仔虫15～20万体を取り出し，水温25°Cのシャーレの中で小型甲殻類と接触させた。

仔虫は接触10分後にはチグリオパスの胃の中に，30分後には多くの供試生物の胃，腸内に摂取されたが，一方では生きたまま腸内の粘液物に包まれた状態で排泄されるのが観察された。1時間後の検鏡で，10尾のチグリオパスのうち2尾に仔虫が血体腔に移行したものがみられた。

供試した小型甲殻類について接触1時間後における消化管内への仔虫の摂取状況および24時間後における血体腔への仔虫の移行の有無を観察したのが Table 2. である。しかし，これらの宿主は2日目にはすべて

斃死したので，その後の観察はできなかった。しかし，この実験結果から，チグリオパスをはじめ2，3の橈脚類が本種の中間宿主となり得ることが明らかになった。

Table 2. Infestation of the larvae into the internal organs of copepods after the experimental exposure.

Items / Species	1 hr. after infection		24 hr. after infection	
	Number of copepods examined	Number of the copepods whose digestive organs infected with the larvae	Number of copepods examined	Number of the copepods whose hemocoel infected with the larvae
Tigriopus japonicus	15	15	10	10
Microsetella sp.	5	1	3	1
Macrosetella sp.	4	1	3	1
Calanus helgolandicus	8	1	2	0
Paracalanus parvas	5	1	3	0
Acartia clausi	3	1	2	0
Oithona nana	4	0	5	0
Paranthura japonica	10	2	5	0
Ericthonicus pugnux	8	1	4	0
Protella gracils	7	0	3	0
Nauplius of *Cirripedia*	3	0	5	0
Juvenile of *Peraeus japonicus*	5	1	5	0

2　仔虫の中間宿主への侵入生態

実験は1973年9月19日に採集したスジハゼから母虫5尾を得て，それから得られた仔虫を供試した。

母虫から取り出した仔虫はシャーレの海水中で1時間後でも浮游しているものがみられるが，多くは器底に沈降し，感染実験で宿主の餌料として投与したクロレラ *Chlorella* sp. など他物を介して蝟集し，器底から立ち揺れ動くような状態で活発に運動していた (Fig. 3.)。

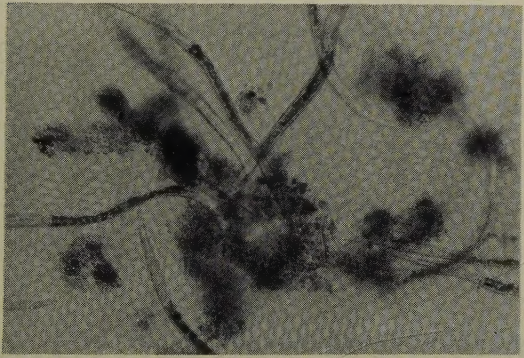


Fig. 3. The active first-stage larvae libareted to the sea water from the uterus of gravid female.

仔虫の水温に対する抵抗性とそれに対応する感染力を調べるため，シャーレに海水300ccを入れ，25°C，21°C，18°C，10°Cの4段階に設定した水温条件下で，39,600±3,200体（n＝5）の仔虫に対してチグリオパス206±25尾（n＝5）を接触させた。結果は Table 3. のとおりである。すなわち，18°C以上では1日後の観察でほぼ全数のチグリオパスの血体腔に平均2.4～3.3体の仔虫の侵入が認められたが，10°Cでは全くみられなかった。このばあい，18°C以上の水温では仔虫および宿主の運動が活発であったが，10°Cの水温下では仔虫の運動力がきわめて弱々しく，また，宿主も不活発であったことが，侵入の制限要因となったと考えられた。

Table 3. Infective rate and number of larvae found in the hemocoel of copepod at different temperature.

Days of after exposure	Items \ Temperature (℃)	25	21	18	10
1	Infective rate (%)	80	90	80	0
	Number of larvae invaded	2.4±2.7	3.3±1.7	3.1±2.1	0
2	Infective rate (%)	100	100	100	0
	Number of larvae invadad	3.4±2.2	4.2±1.7	3.7±1.9	0
4	Infective rate (%)	100	100	100	0
	Number of larvae invaded	5.2±2.9	5.5±1.8	5.4±4.1	0

母虫からの脱出後の経過日数による仔虫の感染力を調べるため，仔虫を20℃の恒温水槽中に収容しておき，経過日数ごとに仔虫約4,000体に対してチグリオパス20尾を接触させて仔虫の感染率を観察した結果がTable 4. である。母虫から脱出した仔虫は3日目までは活発な運動力を有しているが4日後には次第に弱まり，5日目以降は斃死しはじめる。脱出後の経過日数ごとの感染率と仔虫の侵入尾数をみると，上記の仔虫の活力と関連が認められ，3日目まではほとんどの宿主の血体腔への感染がみられるが，4日～6日目のものでは次第に低下し，7日後では全くみられなくなる。侵入尾数についても同様な傾向がみられた。すなわち，母虫から泳出した出した仔虫は，脱出後3日間はほとんど変らない感染力を有するが，やがて低下し，5～6日目以降では感染が起きなかった。

Table 4. Survival and percent infection of larvae after emergence into the seawater from gravid worm.

Items \ Days after emergence from worm	1	2	3	4	5	6	7
Survival rate (%)	100 (n=10)*	100 (n=10)	100 (n=10)	100 (n=10)	62.0 (n=50)	55.6 (n=36)	41.6 (n=48)
Infective rate (%)	100 (n=10)**	100 (n=10)	90 (n=10)	40 (n=10)	30 (n=10)	3.3 (n=59)	0 (n=20)
Number of larvae found in the hemocoel of copepod at 24 hrs. after exposure	2.8±1.7	3.4±2.0	2.8±2.3	1.2±1.7	1.0±0	1.0±0	0

*n Numbr of larvae examined
**n Number of copepods examined

3 仔虫の発育と形態変化

実験は1973年10月18日に採集したスジハゼから母虫3尾を得て，それから人為的に脱出させた仔虫を供試した。

シャーレに海水400ccを入れ，20℃恒温の条件下で約10万体の仔虫に対してチグリオパス約500尾を17時間接触させた結果，血体腔への侵入尾数の平均は2.5±1.2尾（n=20）であった。このチグリオパスをクロレ



Fig. 4. A copepod, *Tigriopus japonicus*, in which the hemocoel infested with several larvae of *Philometra mariae*

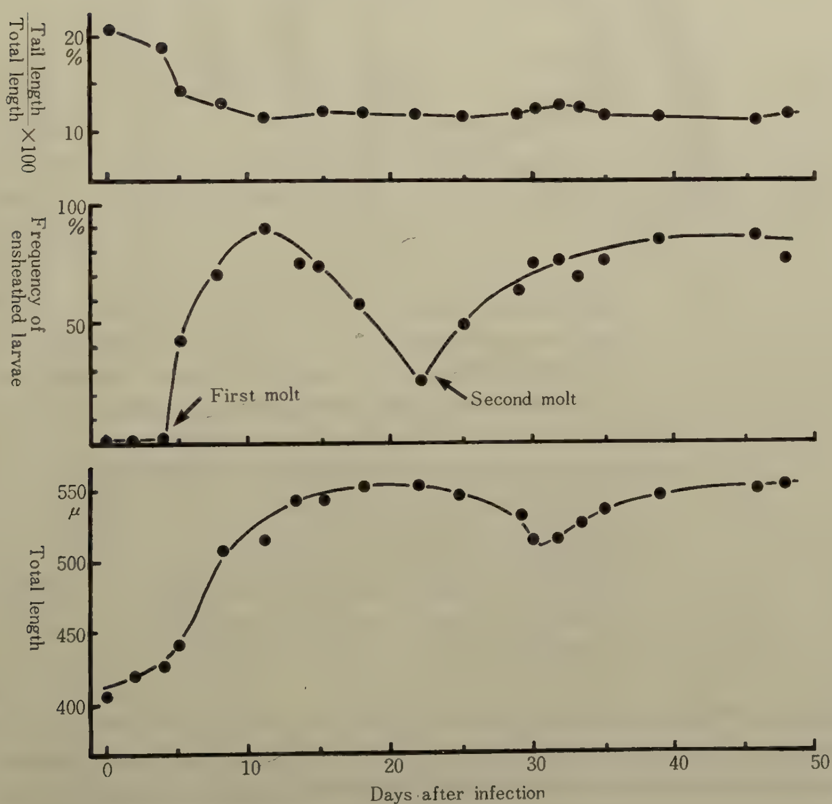


Fig. 5. Morphological changes of larval stages of *Philometra mariae* developing in the hemocoel of *Tigriopus japonicus*, reared in seawater at 20 ℃.

ラを餌料として20℃の条件下で48日間飼育した。

観察は適当間隔の日数で，5～10尾のチグリオパスを取りあげ，宿主の血体腔内に侵入していた仔虫を体外へ取り出し検鏡した（Fig. 4）経過日数にともなう仔虫の外部形態の変化は Fig. 5 に，内部諸器官の発達は Fig. 6 に示した。

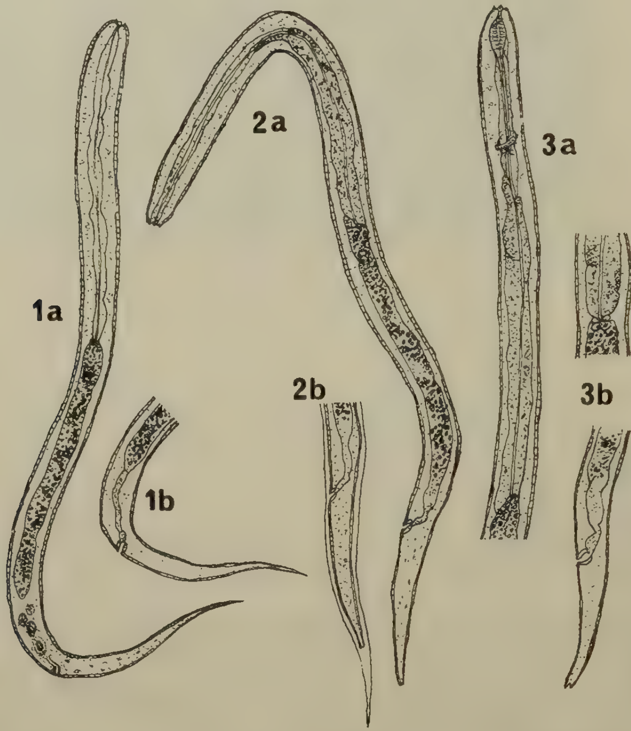


Fig. 6. General anatomical features of larvae in different stages of development.

1a. First-stage larva from the uterus of gravid worm.

1b. Posterior end of the first-stage larva obtained from the infected copepod after 2 days reared.

2a. Second-stage larva dissected from the hemocoel of the infected copepod after development for 5 days.

2b. Same, showing a loose sheath.

3a. Third-stage larva obtained from the hemocoel of the infected copepod after for 25 days reared.

3b. Showing the end of the esophagus and tail of the third-stage larva.

成熟雌虫から取り出した第1期幼生は，すでに述べたように，尾部は尖った糸状型で，食道は未発達の同質同形の管状を呈し，腸は薄い壁の単純な管からなり後腸とは結合していないが，宿主の血体腔へ侵入2日後に，腸と後腸の結合が明確にみられるようになり，腸は肛門と連がる。

第1回目の脱皮は感染5日目ごろから始まり第2期幼生となる。第2期幼生の特徴は次のとおりである。宿主の血体腔内での動きは第1期幼生にくらべていちじるしくゆるやかになる。形態的には，尾部は短かく

急に尖っているようにみえる。肛門から末端まで尾部長の体長に対する比率（尾部長/全長×100）でみると，第１期幼生の21％に対し，第２期幼生になると11～13％となり，これはその後もほとんど変化なく経過する。食道はこの時期を境に狭い筋肉性部と幅広い食道腺部に分れる。仔虫は脱皮した外殻に被鞘している。

第２回目の脱皮の時期は脱皮現象の観察からは明確にすることはできなかったが，感染後22日以降30日ごろまでの間に行なわれたものと推察された。

すなわち，(1)第２期幼生は脱皮殻を被鞘しており，その率は12日目には91％に達したが，その後次第に低くなり22日目には25％になった。被鞘仔虫は次の脱皮に備えて脱鞘するので，このごろが第２回目の脱皮前と考えられる。(2)Platzer[6]らは脱皮後の体長はは一般に小さいとしているが，Fig. 5 の体長変化に示されるように本実験でも22日から30日までは平均体長は次第に減少している。これは脱皮後にみられる体長変化の傾向と一致しており，このころを境に２回目の脱皮があったと考えられる。(3)内部諸器官はこのころを境にして，筋肉性の食道前端部にやや膨出した食道前頭球が発達する。また，食道腺部は長くその幅も体幅一杯を占めるまでになり，その末端の腸内への突出構造 Venticular appendix が観察されるようになる。これらの形態上の特徴は，第２期幼生とは明らかに区別されることから第２回目の脱皮は感染後22日を境として行なわれると考えられる。

感染後40日頃になると体長はほぼ一定し，被鞘生仔虫の出現率も80％前後を示し，宿主の血体腔での運動もやや活発となり，内部諸器官の変化はみられず第３期幼生の感染仔虫として発育する。

考　　察

８月から９月にかけて宿主の鰓蓋部などの表皮下に包嚢を形成するのは，産仔するための成熟雌虫の最終の移行である。包嚢から体が露出し，海水に直接触れた成熟雌虫は間もなく体壁が裂開して子宮は体外に突出し仔虫を放出する。このばあい，宿主の游泳によって仔虫は広範囲に撒播されるが，これは中間宿主への感染を高めるのに役立つ。さらに室内実験で観察された器底での仔虫の蝟集行動は自然域でも適応され，脱皮後海底へ沈降し他物を介して立ち揺れ動くような行動をとる仔虫は匍匐性の橈脚類による摂取を容易にしていると考えられ，寄生生態として興味深い。

感染初期の仔虫の行動として，石井[7]は淡水産の *Pilometra carassi* で，適正な中間宿主では消化管内に摂取された仔虫は数分～10数分で腸壁を貫通して血体腔へ移行するとしているが，本実験では仔虫はチグリオパスの胃や腸内に摂取されても初期摂取群では腸内の粘液物に包まれた状態でそのまま排泄されてしまう。このように摂取，排泄を繰り返し，30分経過以降に摂取された仔虫群のみが血体腔へ侵入することが観察されたが，これが仔虫の活力の強弱によるものかどうかについては明らかにすることはできなかった。

宿主に対する仔虫侵入の影響を知るために感染３日目において，24時間以内に斃死したチクリオパスの血体腔内の仔虫数を生存群と比較した結果，前者の平均仔虫数は7.3±2.5尾（ｎ＝20），後者は2.9±1.9尾（ｎ＝20）であり両者の間には有意の差が認められた。このことは仔虫を感染させた宿主を長期間飼育するにはその仔虫数を３尾程度に押える必要があることを示唆している。本実験は，宿主１尾あたりの仔虫の侵入数を2.5±1.2尾（ｎ＝20）に押え，20℃の水温条件下で，クロレラを餌料として飼育した結果，実験上の資料を得るために必要とした10尾程度の仔虫の採集というう えでは48日間，さらに仔虫１尾のみが採集されたばあいを入れると61日間の飼育を継続することができた。感染後61日目に得られた仔虫は48日後のものとくらべて形態上の変化はみられなかった。

宿主内で２回脱皮した第３期幼生を感染仔虫と考えてよいかについては感染実験を予備的に試みた。秋期に自然海域から採集したものでは完全未感染のスジハゼ群は得られなかったが（感染率$2/10$），これらの群のスジハゼに，１回目の脱皮をおえた被鞘性の第２期幼生（感染後15日目）を，また２回の脱皮をすませた第３期幼生（感染後39日目）を，宿主とともにガラス管製のカテーテルを用いて胃中へ挿入，人為的に摂取さ

せた結果，前者では感染率の変化はなかったが，後者ではすべてのスジハゼにおいて生殖腺内に仔虫の存在を認めた（6/6）。

自然感染に由来する仔虫が全くない宿主を用いての感染実験で寄生生態を詳細に調査する必要があるが，これまでの予備的な実験結果から考えて，２回の脱皮をした第３期幼生は最終宿主へ侵入可能な感染仔虫と考えてほぼ誤りはないと見られる。

今後は最終宿主内での仔虫の発育，移行などに関する生態研究を実施したい。

要　　　　約

海産底棲類に寄生する線虫について，胎生仔虫の発育経過の観察と中間宿主への感染実験を試み以下の結果を得た。

1. 胚発生は母虫の子宮内で行なわれ，第１期幼生は８月から９月にかけて生産される。仔虫の体壁の裂開によって海水中へ産出される。８～20㎜の母虫の子宮内仔虫は２～10万尾を数える。
2. 成熟母虫からとりだした第１期幼生を中間宿主と想定される橈脚類へ感染させたところ，２，３の橈脚類で感染に成功した。経口的に橈脚類に摂取された第１期幼生は腸壁を貫通して血体腔に入り，２回の脱皮を経て第３期の感染仔虫として発育する。
3. 仔虫は水温20℃で４日までは高い生存率を示すが，以降は斃死固体が増える。高い感染率を示すのは３日以内であった。
4. 成熟母虫および橈脚類の血体腔内における仔虫の発育と形態的特徴は下記のとおりである。

(1)　第１期幼生

母虫の子宮内仔虫から得られた第１期幼生は体長360～460μ，体幅14～15μで，細長く尖った尾部をもつ。

頭部には三叉した口唇がみられる。食道は同質同形の筋肉性の管状で，その末端は腸内に連結している。腸は後腸とはいまだ結合していない。肛門は体の後方から85～95μのところに位置している。

宿主の血体腔に侵入した仔虫は活発に運動し，２日後には腸は後腸と結合する。

(2)　第２期幼生

水温20℃で，感染後５日目頃から第１回目の脱皮が行なわれ，脱皮殻を被鞘した第２期幼生となる。宿主の血体腔での動きはゆるやかになり，尾部は短かく急に尖っている。食道は狭い筋肉性部と幅広い食道腺部に分れる。

(3)　第３期幼生

第３期幼生は20℃で25日後以降の橈脚類で発見された。第２期幼長と異なるところは，筋肉性の食道前端部にやや膨出した食道前頭球が発達し，食道腺部は巾広く，その末端端部の腸内への突出構造が観察されるようになる。宿主の血体腔での運動も比較的活発になる。

文　　　　献

1）山口義昭・阪口清次・後藤幹夫，1973：海産底棲魚類に寄生する線虫に関する研究—1. 広島湾北西沿岸域における分布と成虫の形態，本誌，６，９—16.

2）Rasheed, S. 1963: A revision of the genus *Philometra costa*, 1845. J. Helminth., 37, 89-130.

3）Yamauti, S., 1961: Systema Helminthum, III, 74-77.

4）Thomas, L. J., 1929: *Philometra noduiosa* nov. spec. with notes on the life history. J. Parasitology, 15(3), 193-199.

5）Furuyama, T., 1934: On the morphology and life-history of *Philometra fujimotoi* Furuyama, 1932. Keijio J. Med, 5, 165-177.

6）Platzer, E. G., & Adams, J. R., 1967: The Life history of a Dracunculoid, *Philometra oncorhynchi*, in *Oncorhynchus nerka*, Can. J. Zool., 45, 31-43.

7）石井重美，1931：日本産魚類の寄生虫９．岩波講座生物学18別項，179—207.

Bull. Nansei Reg. Fish. Res. Lab. (8) 11~20 (1975)

Some Haematological Properties of Matured Red Sea Bream, *Chrysophrys major* TEMMINCK et SCHLEGEL

Hiroko Ishioka and Tohru Fushimi*

Many haematological properties in the fish have been studied to utilize to the diagnosis of diseases, the evaluation of effects of pollution, and the fundamental physiology.

Prominent changes in certain of the blood properties of human and other higher vertebrates often occur under the condition of disease and are successfully distinguished from those of healthy ones. On the other hand, it has been well known that the haematological characteristics of the healthy fish were ranged widely, and also the physiological characteristics affected by the external environmental conditions change the values considerably. Although the need has been stressed for the establishment of the standard range of normal haematological values, the achievement is not so notable regardless of the efforts put into the research.

In the case of standardizing the haematological values for the diagnosis of disease, the physiological range of variation of these values of the fish should be established. It is a very important subject of haematological studies that how the blood values are influenced by the change of external or internal conditions such as the osmotic pressure of the medium or maturation and spawning.

As one of these subjects, the present study had the purpose to clarify the effects of maturation on the haematological characteristics, especially on the electrophoretic patterns of the serum proteins.

The authors would like to acknowledge the continuing guidance and encouragement of Dr. Masaru Fujiya, Freshwater Fisheries Research Laboratory and Dr. Seiji Sakaguchi, Nansei Regional Fisheries Research Laboratory. We are also grateful to Dr. Hisao Ozaki, the professor of Tokyo University of Fisheries, for providing related reports and a critical reading of the manuscript.

Materials and Methods

The present study was carried out from March, 1972 to February, 1973.

Red sea breams applied for this investigation were hatched at the same time, reared and cultured in fish preserves under the routine culture techniques at Hiroshima Prefectural Fisheries Experimental Station for 3 years. For growth of these fish, mixture of 49.5 % minced raw fishes (sand eel or mysid shrimps) and 49.5 % synthetic diet for rainbow trout and 1 % Halver type vitamin mixture were fed. In spawning season, from March through June, tocopherol drugs were added at 1 % to the diet.

Received: June 12, 1975. Contribution No. 47
from the Nansei Regional Fisheries Research Laboratory.
* Hiroshima Prefectural Fisheries Experimental Station

Specimens were anesthetized in about 1/5000 tricaine methane sulfonate (MS 222) sea water solution for the collection of the blood samples and the dissection.

After the measurement of the gonad weight and morphological characteristics the gonads were removed and fixed in Bouin's solution for histological observation. The blood samples were collected by excising the caudal fin in 5 ml syringe contained anticoagulant solution (Anglot ET) and were put in plane glass tubules. The blood in the syringe was applied for the analysis of values on haemoglobin, haematocrit and protein of the plasma. The bloods in the plane glass tubules were prepared for electrophoresis. The serum was separated with the aid of gentle centrifugation after clotting of the blood. Then, the sera were refrigerated at $-20°C$ untill the operation of electrophoretic analysis.

The haemoglobin contents were determined with the simplified method of haemometer[1], and the haematocrit values were determined by the micro-haematocrit method using micro-capillary centrifuge. The values of protein concentration of the serum were determined by Hitachi-Protein-meter (refractometer).

The electrophoretic analysis was primarily carried out following the standard method of the Society of Electrophoresis[2].

For electrophoresis, a Toyo Model SE-2 microzone chamber was employed using cellulose acetate membrane. It was powered by Toyo Electric Currentmeter Model No. III BA 8-2. Before the application of sera on the cellulose acetate membrane, they were concentrated to 10 - 12 % of protein on refractometer by air vacuum pump, then, 1 μl of the serum was employed. All runs were for 65 min. at a constant current of 0. 8 mA/cm with the veronal buffer.*

The cellulose acetate membranes were stained with Ponceau 3 R reagents and decolorized in 1 % acetic acid solution and then dried in the customary manner. They were scanned with the Toyo Densitrol.

Results

The sampling of the blood was carried out once a month, and in the spawning season, twice a month. In principle, 12 fish were randomly supplied for dissection from the fish preserve in the sea.

The seasonal changes of gonad index and the state of the ovary are represented in Fig. 1. The state of ovary is divided into two phase, developmental and immature. The former ovary had the oocytes with yolk globule and the latter only had the oocytes without yolk globule under histological observation.

The comparisons of condition factors and some blood properties of male and female are presented in Table 1.

Haematocrit values and haemoglobin contents seem to be higher at the begining of the maturation and then decrease gradually to August and then also increase slightly to November. However, these changes are not so significant.

* Veronal ············2.76g
Veronal-Na ······15.45g
in 1000 ml of distilled water (pH: 7.725, μ:0.075)

Table 1. Seasonal changes in some blood characteristics, condition factor and gonad weight in red sea breams.

Date	No. of Fish Examined		Body Length (cm)	Body Weight (g)	Condition*1 Factor	Gonad Weight (g)	Hematocrit Value (%)	Hemoglobin Content (g/dl)	Protein Value (g/100ml)
'72, 3, 27	F*2	6	30.6±1.85	947.5±124.6	32.3±2.64	26.2±7.97	48.3±4.5	9.3±1.40	8.4±0.8
	M*3	5	31.1±1.94	944.0±147.6	29.8±1.69	40.5±7.48	47.5±4.7	9.4±0.82	6.2±0.8
4, 14	F	6	30.5±1.67	892.5±149.0	29.7±2.56	47.6±27.4	44.0±4.5	8.4±0.85	7.3±0.5
	M	6	28.8±2.23	766.7±106.7	30.7±3.74	35.5±11.9	41.5±6.3	8.3±1.18	5.7±0.9
4, 27	F	6	30.8±2.23	900.0±110.1	29.5±4.93	49.4±25.4	38.0±4.1	7.0±0.47	7.1±0.7
	M	6	31.2±1.65	905.8±151.1	28.2±1.72	45.1±12.4	45.2±5.4	7.2±1.96	5.7±1.0
5, 15	F	7	31.8±4.72	1059.3±417.3	29.5±1.55	73.1±31.0	43.8±7.1	8.2±0.91	6.1±1.7
	M	5	31.2±3.71	976.3±334.7	29.2±1.30	60.2±28.8	43.5±7.5	8.2±0.82	5.4±1.7
5, 29	F	7	28.8±1.99	741.3±125.2	28.8±3.10	52.2±35.7	41.2±6.1	7.6±0.85	5.2±1.1
	M	5	28.7±1.82	754.0±143.3	30.1±1.57	35.3±8.50	40.5±0.9	7.9±0.82	4.3±0.2
6, 15	F	6	29.4±2.23	752.5±170.4	27.3±0.70	53.9±19.6	38.3±5.4	7.2±1.12	4.9±0.6
	M	5	30.1±1.88	765.0±119.4	27.0±0.89	22.2±6.14	40.2±4.1	7.7±0.98	4.8±0.8
6, 29	F	6	32.8±4.09	1070.8±387.6	29.0±3.08	13.7±12.8	42.6±4.4	8.1±0.72	4.9±0.8
	M	6	30.7±2.57	879.2±241.4	29.3±3.74	17.8±7.94	39.3±3.6	8.1±0.86	5.2±0.9
7, 17	F	7	32.2±3.03	1025.7±279.6	29.9±2.69	6.2±1.60	41.4±2.7	8.0±0.60	4.9±0.5
	M	5	30.3±1.36	814.0±106.6	28.9±1.14	3.6±0.76	44.1±2.3	8.4±0.70	5.4±0.5
8, 14	F	4	33.2±2.70	1215.0±225.3	33.2±6.34	7.4±0.97	36.9±1.2	7.8±1.13	6.1±0.7
	M	8	29.9±2.94	827.5±175.6	30.8±2.61	2.0±0.75	39.7±2.1	8.1±0.81	5.9±0.7
10, 17	F	4	32.7±2.54	1100.0±230.5	31.3±3.53	7.1±3.28	35.8±2.2	8.6±1.11	5.6±0.6
	M	8	31.2±1.40	1020.0±179.3	33.1±1.89	2.5±0.97	37.9±3.8	8.9±0.70	6.2±0.8
11, 16	F	1	32.1	1060	31.8	7.9	40	8.7	5.0
	M	11	32.2±3.66	959.4±294.2	28.0±2.58	2.4±0.80	43.4±3.2	9.1±0.54	5.2±0.5
'73, 2, 16	F	2	33.6±0.35	1220.0± 70.7	32.2±2.86	6.6±1.06	41.3±1.8	9.6±0.57	5.4±0.1
	M	4	31.1±3.01	921.3±316.4	29.5±2.10	7.1±0.85	41.8±1.6	9.2±0.24	4.4±0.8

*1Condition Factcr : $\frac{(\text{Body Weight})^3}{(\text{Body Length})} \times 1000$ F*2 : Female M*3 : Male

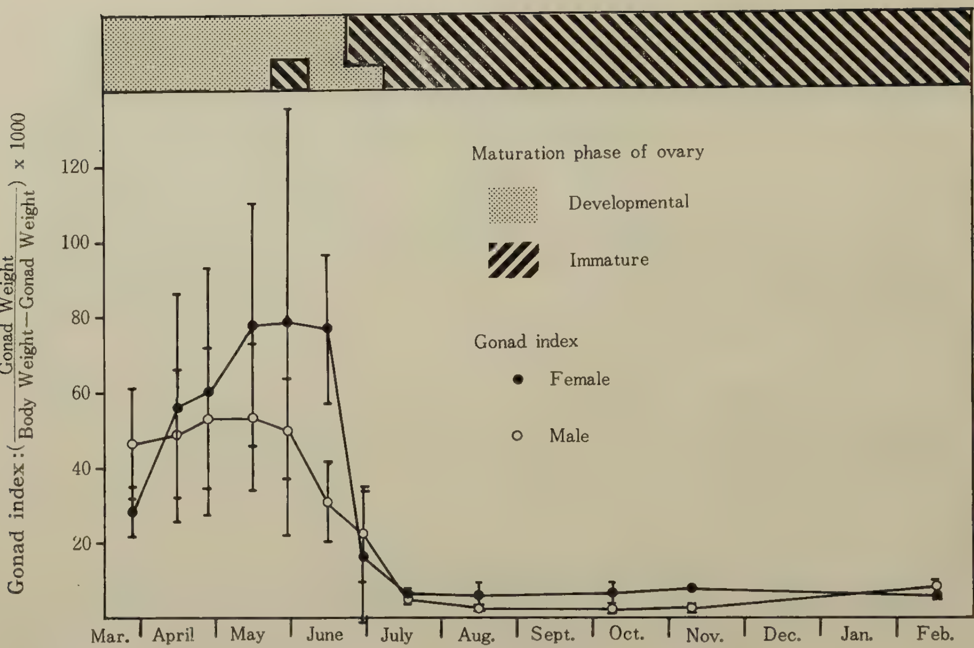


Fig. 1. Seasonal changes in gonad index and histological phase of ovary in red sea breams.

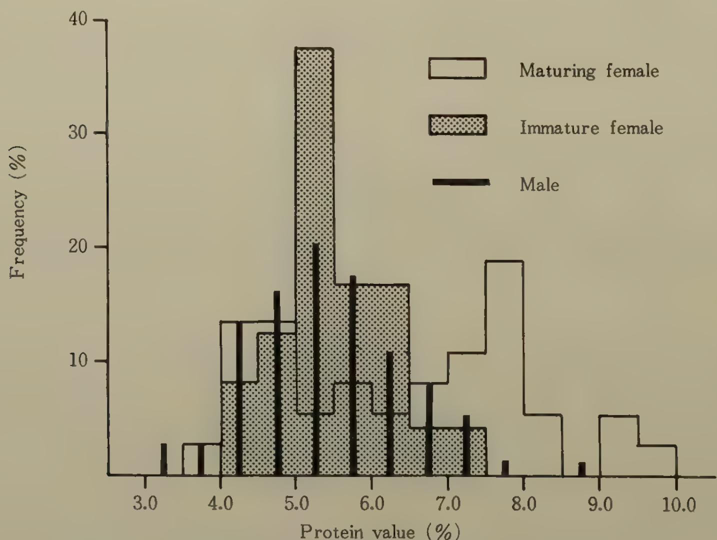


Fig. 2. Distribution of protein values determined by refractometer in red sea breams.

Among examined blood properties, the values of serum protein concentration measured by refractometer showed the great changes and variations, especially the females' was higher than that of the male in maturing period. The values of

protein concentration are presented in Fig. 2 on male, immature female and matured female following the developmental stages of gonads judged from histological observation.

The results of maturing female showed the peculiar feature of the distribution of protein concentration with the wider range of variation.

The results of electrophoresis are shown in Table 2 and a representative film and its corresponding densitometer profile are illustrated in Fig. 3. No attempt was made to identify the protein components of the sera studied as albumin or globulins, and the electrophoretic fractions were numbered in order of increasing mobility to the positive pole. As illustrated in Fig. 3, this profile is divided into 6 fractions.

Table 2. Results of electrophoretic analyses on serum proteins of red sea breams.

	Fraction	I	II	III	IV	V	VI
Migration distance from origin (cm)	Female 1* (n =37)	2.76 0.35	1.64 0.35	0	1.10 0.28	2.40 0.30	3.02 0.31
	Female 2** (n =24)	2.80 0.24	1.61 0.13	0	1.02 0.16	1.99 0.19	2.92 0.24
	Male (n =74)	2.67 0.35	1.55 0.28	0	0.95 0.19	1.90 0.24	2.84 0.29
Relative distance***	Female 1 (n =37)	91.2 9.2	53.9 9.8	0	35.9 8.0	78.0 7.3	100
	Female 2 (n =24)	95.2 6.9	54.9 4.9	0	34.5 4.9	68.4 5.5	100
	Male (n =74)	93.7 8.9	54.4 7.8	0 0	33.4 5.3	66.5 5.0	100
Relative area composition (%)	Female 1 (n =37)	1.2 0.8	28.0 4.5	45.2 6.3	7.0 3.0	14.3 4.3	3.1 1.4
	Female 2 (n =24)	3.0 1.9	22.1 4.4	54.7 7.1	6.9 3.7	6.2 2.5	6.6 3.3
	Male (n =74)	2.3 1.8	24.9 5.1	52.6 5.3	7.4 3.1	6.9 2.6	5.5 2.9

(n= : No. of fish examined)

For each component, mean values are represened as the value of first reading and standard deviation as one of second reading.

Female 1* : Females with developing oocytes.

Female 2**: Females with immature oocytes.

*** : The relative migration distance was calculated as the ratio of migration distance to that of fraction VI.

Fraction I contains the faint band most rapidly migrating to the positive pole and the fraction VI the band most rapidly migrating to the negative pole. The relative mobility of these bands migrated from the starting point are almost consistent. The fraction V of the maturing females, however, as presented in Table 2, is slightly different in relative mobility from those of the males and the immature females. This band of maturing female, numbered V', may probably be

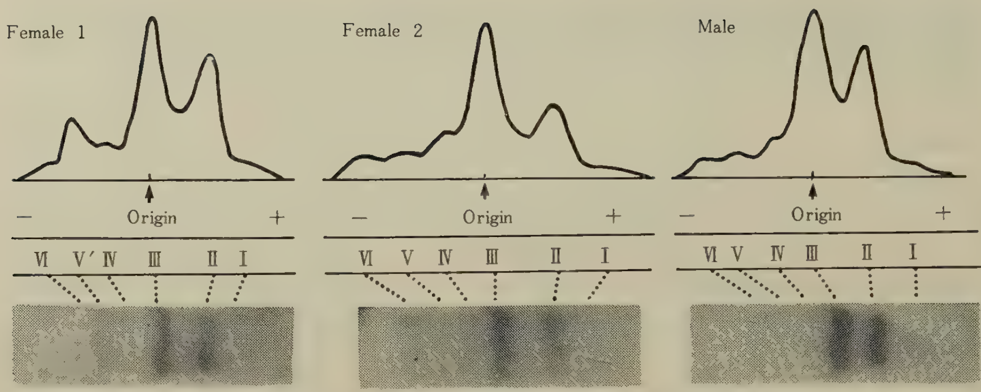


Fig. 3. The representative electrophoretical patterns and their corresponding densitometer profiles of serum protein in red sea breams.

composed of band V and other different protein fraction relating to the yolk formation.

As illustrated in Fig. 1, the histological observations were made from the standpoint of the appearance of yolk globules and these results were closely related with the patterns of sera proteins on electrophoresis. Although the patterns of males and immature females without yolk globules in the oocytes are almost constant all the year round, those of females with yolk globules in the oocytes are characteristic, and the characteristic feature is appeared on fraction V.' Further, during these investigations, 2 fish had the seminal glands with small ovarian tissues. These ovaries had not the oocytes accumulating yolk substances, and the electrophoretic patterns of serum proteins from those fish showed the same pattern as male showed.

Discussion

Recently, basic informations of the spawning of red sea breams have been published.[3)4)] They have a long spawning period over two monthes from April to June and the maturation process begins on late March.

There are some papers about the problems on the blood properties on maturation process. Gelineo[5)] observed the high haemoglobin concentration on several fishes during maturation period. On the other hand, it was reported by Sano[6)7)] that haematocrit values and haemoglobin contents fell remarkably with the development of gonads in both sexes of cultured rainbow trout, and was considered that these phenomena were due to the depletion of nutritive substances by spawning.

In the present study, condition factors, haemoglobin contents and haematocrit values are on the decrease slighly during the latter half period of the spawning season. These results may support the assumption that a small range of variation in these values results from active feeding even in spawning season in red sea breams.

Some research results on the electrophoretic patterns of serum proteins of red sea breams have been reported by Saito[8)9)] on Tiselius method and on paper electrophoresis. According to the results, five fractions, f, I, II, III and IV were identified while authors' obtained are six fractions. The fraction I is a faint band and often looks like the tailing of fraction II. The patterns also different from that of Saito, and it is supposed that these discrepancies may be depended upon the difference of the method applied.

Matsuura[10)] represented the maturation stage of ovarian eggs of red sea breams with the histological observation, and the maturation of ovary was divided into three phases, such as immature, developmental and maturation. These phases correspond to peripheral nucleolus stage, phase from yolk vesicle stage to later yolk globule stage and that from migration nucleus stage to maturation stage respectively. Red sea breams spawn several times and have all stages of oocytes in the ovary throughout the spawning season. In the present study, it was clarified that the characteristics of the electrophoretic patterns of serum proteins of female depend on the developmental phase of ovary. In spawning season, the fish with ovary having only peripheral nucleolus oocytes did not show such characteristic pattern of serum protein.

In red sea breams, hermaphrodism is observed on several times. Kitajima, C. and T. Fushimi[11)] reported that this hermaphrodism was mostly observed in younger matured fish, about 2-3 years old, in the appearance rate of 20 - 30 % under cultured and natural condtions. These fish always had the seminal glands with various sized ovaries and these ovaries had no oocytes in developing phase. These facts may be the results from deficient supplies of substances necessary for yolk formation by blood stream.

Studies on the pattern changes of electrophoresis relating to the gonad maturation showed positive or negative results. Sindermann C, J, and D. F. Mairs[12)] had found no major changes in serum patterns attributable to reproduction or to fresh water migration on anadromous alewives, *Alosa pseudoharengus*. Drilhon A. et J. M. Fine[1,3)], however, reported the fraction a little to the anode on starch gel electrophoresis concerning the female gonad maturation on the salmon, *Salmo salar*. Yamashita[14)] reported that on scorpion fish, *Sebastiscus marmoratus,* the fraction V, migrating to the negative side, was higher on the electrophoretical pattern by cellulose acetate membrane on the female before the extrusion of fries.
Although this resembles to the results obtained by the present study, it is uncertain whether the physiological changes occurring in the maturation process of viviparous fish are similar to that of the oviparous fish. To know the pattern variations attributable to sex and maturity, the gel electrophoretic analyses of sera from rainbow trouts, *Salmo gairdneri,* were made by R. V. Thurston,[15)] who obtained ten fractions numbered from I, the fraction nearest to the positive pole, to X, the fraction nearest to the negative pole. Primarily there were not pattern variations attributable to sex but the maturity had the characteristic effects on the patterns in band intensities of fraction VI and fraction IX. W. E. Vanstone

and F. Chung-Wai Ho[16] reported on coho salmon, *Onchorhynchus kisutch,* that on the paper zone electrophoresis, bands were divided into six fractions from I of the positive side to VI of the negative side and the fraction IV was appeared only in the sera of maturing female. Aida, K., Phan-Van-Ngan and T. Hibiya[17] also reported on the starch gel electrophoresis that there are 15 fractions on females of Ayu, *Plecoglosus altivelis,* and fraction nine and eleven showed the distinct increase in maturation period, and both fractions became stainable with Sudan Black B, as these increased on the concentration. On *Onchorhyncus keta, O. nerka.* and *O. masou,* Hara[18] reported the appearance of the new fraction at the position of β-globulin on cellulose acetate membrane.

In spite of the differences of the methods, the results show the similar intensity increase patterns of a fraction in the position of inclination towards negative side in the maturing female when the changes on electrophoretical patterns of serum attributable to the ovary maturation are recognized on Saimonina.

In the present study, the values of the protein concentration by refractometer showed the characteristic bimodal distribution on matured females and the higher mode may contain the lipid component. It seems that the fraction V' is almost the same as the serum protein specific for female by Aida et al. concerning the state of appearance and the position of inclination towards negative pole.

From the discussions described above, it is assumed that the appearance of the female-specific protein with the development of oocytes supports that the yolk substances are synthetized in the organ other than ovary and provided into the oocytes with blood streams. Further, it may be indicative of the analogous mechanism on yolk accumulation in the oocytes among fishes that there are something in common on the electrophoretical characteristics of female-specific protein during maturation, whereas there are differences in species and in analytical methods. These are the subjects for future studies.

Summary

Some blood properties, haemoglobin contents, haematocrit values, values of protein concentration by refractometer and electrophoretic patterns of the serum protein were determined relating to the maturity process of gonads on red sea breams, *Chrysophrys major* Temminck et Schlegel. While condition factors, haemoglobin contents and haematocrit values decreased slightly in the late spawning season, the values of protein concentration showed the extreme increase in the begining and the decrease in the late of the spawning season on females. Electrophoretic patterns on cellulose acetate membrane of blood serum proteins disclosed the characteristic feature in the female with the oocytes of developing phase.
This was the appearance of the fraction V' a little to the anode, and it may be identified as the female-specific serum protein as that seen on Salmonina concerning to the state of appearance and its position.

References

1) Matsusato, T., & C. Kitajima, 1972: The Comparison of Haemoglobin Determination Methods for Diagnosis of Fish Disease (in Japanese). The Aquiculture, **19** (3), 121—127.

2) The Society of Electrophoresis, 1967: The Experimental Method for Electrophoresis (in Japanese). the 4 th edition, pp. 443, Bunkodo

3) Kitajima, C., & T. Fushimi, 1969: On the Spawning of Red Sea Breams Cultured for 2 Years (in Japanese). The Aquiculture, **17** (1), 11—18.

4) Koga, F., Y. Tanaka, & A. Nakazono, 1971: Observation on Spawning of Red Sea Bream, *Chrysophrys major* Temminck et Schlegel, and Black Sea Bream, *Mylio macrocephalus* (Basilewsky),in Aquarium (in Japanese). Report of Fishery Research Laboratory Kyushu University, (1), 83—89.

5) Gelineo, S., 1957: Le taux l'hemoglobine sanguine de pleusieurs espéces de poisson de mer. C. R. Soc. Biol. Paris, 151, 1594.

6) Sano, T., 1960: Haematological Studies of the Culture Fishes in Japan 3. Changes in blood constituents with growth of rainbow trout. The Journal of the Tokyo University of Fisheries, **46** (1—2), 77—87.

7) Sano, T., 1963: Blood Properties of Cultured Fish (in Japanese). Bull. Japan. Soc. Sci. Fish., **29** (12), 1113—1118.

8) Saito, K., 1957: Biochemical Studies on the Fish Blood-VIII. On the Electrophoretic Specificity of Serum Proteins (in Japanese). ibid, **22** (12), 752—759.

9) Saito, K., 1957: Biochemical Studies on the Fish Blood-IX. On the Paper Electrophoretic Analysis of Serum Proteins (in Japanese). ibid, **22** (21), 760—767.

10) Matsuura, S., 1972: Fecundity and Maturation Process of Ovarian Eggs of Red Sea Bream, *Pagrus major* (Temminck et Schlegel) (in Japanese). Sci. Bull. Fac. Agr. Kyushu Univ., **26** (1—4), 203—215.

11) Kitajima, C., & T. Fushimi, 1970: Studies on the Culture of maturing fish on Red Sea Breams (in Japanese), Reports on the Study on Fish Seedling Production (Hiroshima Prefectural Fisheries Experimental Station), 2—13.

12) Sinderman, C. J., & D. F. Mairs, 1961: Blood Properties of Pre-spawning and post-spawning Anadromous Alewives. Fish. Bull. U. S. Fish & Wildlife Service, **61**, 144—151.

13) Drilhon, A., & J. M. Fine, 1963: Dimorphisme Sexuel dems les Proteines Seriques de *Salmo salar* Etude Electrophoretique. C. R. Soc. Biol. Paris, **157** (11), 1897. (translated by Dr. H. Ozaki)

14) Yamashita. H., 1968: Haematological Study of a Species of Rock-fish, *Sebastiscus marmoratus*-IV. Change of the Amount of Blood Elements and the Electrophoretic Pattern of Serum Protein under the Influence of Stress. Bull. Japan. Soc. Sci. Fish., **34** (12), 1066—1071.

15) Thurston, R. V., 1967: Electrophoretic Patterns of Blood Serum Proteins from Rainbow Trout, *Salmo gairdneri*. J. Fish. Res. Bd. Canada, **24** 2169—2188.

16) Vanstone, W. E., & F. Chung-Wai Ho, 1961: Plasma Proteins of Coho Salmon, *Onchorhyncus kisutch*, as Separated by Zone Electrophoresis. ibid, **18**, 393—399.

17) Aida, K., Phan-Van-Ngan, & T. Hibiya, 1973: Physiological Studies on Gonadal Maturation of Fishes-I. Sexul Difference in Composition of Plasma Protein of Ayu in Relation to Gonadal Maturation. Bull. Japan. Soc. Sci. Fish., **39** (11), 1091—1106.

18) Hara, A., 1975: Electrophoretical and Immunological Studies of Fish Serum Proteins. ibid, **41** (1), 105—113.

養殖マダイの産卵期における血液性状について

石岡　宏子・伏見　　徹

同一時期に産卵され，飼育された養殖3年生マダイについて，毎月，採血を行ない，ヘモグロビン量，ヘマトクリット値，蛋白質含量，血清蛋白電気泳動像について測定を行なった。養殖マダイの産卵期は3月から6月までであり，その間，ヘモグロビン量，ヘマトクリット値の変動は極めて小さかったが，蛋白質含量は産卵期初期に高く後期に低下する傾向が認められ，特に雌魚で顕著であった。さらに，産卵期の雌魚の血清蛋白電気泳動像は，卵細胞の成熟と密接な関係があることが明らかになった。すなわち，卵細胞の発育状態が卵黄球期以後の卵巣を持つ雌魚の場合には，血清蛋白パターンは，陽極側から数えて5番目のピークの位置変化，濃度増加という特異性を示し，雄魚および卵黄球期以前の発育段階にある卵細胞だけをもつ雌魚では，周年，ほぼ一定の泳動像を示した。このことは卵黄形成のための物質が卵巣以外の器官で生合成され，これが血流によって卵細胞まで運搬されるためであろうと推考した。

Bull. Nansei Reg. Fish. Res. Lab. (8) 21～27 (1975)

The Zoeal Stages of the Swimming Crabs, *Charybdis japonica* and *Portunus hastatoides* Reared in the Laboratory

Hiroshi KURATA and Shigemi NISHINA

The swimming crabs of the subfamily Portuninae are very abundant everywhere in estuaries and offshores of the Seto Inland Sea. A large number of zoeae and megalopae of many species usually occur together in the plankton in summer and fall when the spawning activity reaches its peak in majority of species. Identification of species of these planktonic crabs, however, is almost impossible at the present circumstances owing to their striking similarity in every essential characters as is already noticed by LEBOUR (1928).

Larval development of certain of the Japanese swimming crabs including *Charybdis japonica* has been the subject of several studies from the view point of morphology (AIKAWA, 1929, 1937), of life history (OSHIMA, 1938) and of rearing (YATSUZUKA, 1952, 1957, 1962). Our knowledges, however, are still far from satisfactory to tell species of larval swimming crabs apart.

This paper presents the descriptions and line drawings of zoeae of the two species of swimming crabs which are very common in the shallow water near the Onomichi Station. This is a part of works finally aiming at the establishment of a key to the larvae of Japanese Portuninae. Measurements were taken according to KURATA (1975).

Charybdis japonica A. MILNE EDWARD

The "ISHIGANI" is very common in shallow waters from Tokyo Bay to Kyushu in Japan, further extending to Formosa, Korea and China (SAKAI, 1939). This is one of the most abundant swimming crabs in the Seto Inland Sea and is caught commercially by gill-nets or by trawls for sale in the local markets.

Berried crabs were separated on May 28, 1974 from the regular trawl catches off Onomichi, and were kept in an aerated aquarium. Eggs hatched out on June 12, and were reared up to stage 4 feeding on rotifers, *Brachionus* sp., and newly hatched *Artemia* nauplii in succession. Unfortunately, megalopae were not obtained.

ZOEA (Fig. 1)

Black chromatophores are present over mouth parts, over stomach, along intestine as far back as abdominal somite 2, and ventrally to hind end of abdominal somites 2-5.

All the spines are present on carapace. Rostral spine is straight and smooth.

Received: August 5, 1975. Contribution No. 48 from the Nansei Regional Fisheries Research Laboratory

It is slightly shorter than carapace in early stages but becomes longer than the latter in later stages. Dorsal spine curves and is hooked at end. It is longer than carapace as well as rostral spine in all stages. Lateral spines are short. Ventral margin of carapace is denticulated and, in later stages, is fringed with sparse setae. Eyes are very large. There is an inconspicuous dorsal knob on carapace above stomach.

There are lateral hooks on abdominal somites 2 and 3, and postero-lateral spines on somites 3-5 in all stages. Postero-lateral spines of somite 3 are slightly shorter than those of somite 4. Telson is slender and typically forked with 2 outer spines, lacking the second. Outer spine 1 is inserted distinctly behind to inner seta 1, and is almost as long as or shorter than outer spine 3. Inner setae are more or less shorter than 1/2 the length of fork. Seta 1 hardly exceeds tip of outer spine 3.

Antennule is simple and unjointed until stage 4. Antenna is much shorter than rostral spine with two rows of spinules along spinous process. Exopod is of moderate length, ending in a short spine with an apical inner spine which is almost as long as the rest of exopod including terminal spine.

Maxillule has a feathered seta on outer edge of basis from stage 2, and a simple seta on outer edge of coxa from stage 3. Endopod of maxillule is of two segments with 1 and 6 setae on proximal and distal segment respectively, and that of maxilla is unsegmented but bilobed with 6 setae in three pairs of which the terminal pair tends to be suppressed. Endopod of maxilliped 1 is of 5 segments and that of maxilliped 2 is of 3 segments.

Stage 1. From spine to spine: 1.14-1.38 mm. in 15 specimens.

Eyes are sessile. Abdomen is of 5 somites plus telson. Rostral spine is slightly shorter than carapace, while dorsal spine is longer than the latter. Lateral spines are about 1/3 as long as rostral spine. Postero-lateral spines on abdominal somite 3 are somewhat less than 1/2 as long as somite 4. Telson is slightly less than twice as long as wide. Fork is 1/2 times longer than the rest of telson. Outer spine 1 is nearly as long as or somewhat shorter than outer spine 3, which bends inward distally. There are 3+3 inner setae.

Antenna has no endopod, reaching to about 3/4 the length of rostral spine. Mandible has no palp. Maxillule has no outer setae. Exopod of maxilla (scaphognathite) is produced proximally into a large feathered seta, and bears another 4 setae along outer margin. Maxillipeds bear 4 swimming setae. There are rudiments of maxilliped 3, but neither legs nor pleopods.

Stage 2. From spine to spine: 1.50-1.86 mm. in 20 specimens.

Eyes are stalked. Rostral spine is slightly longer than carapace. Postero-lateral spines of abdominal somite 3 are about 3/5 as long as somite 4. Telson is somewhat more than twice as long as wide with an extra pair of inner setae inside. Fork is 1/2 times longer than the rest of telson. Outer spine 1 is distinctly shorter than spine 3. Antenna is about 2/3 as long as rostral spine without trace of endopod. Maxillule bears a feathered outer seta on basis.



Fig. 1. *Charybdis japonica*: zoeal stages 1–4. A, stage 1, lateral; B, stages 4, lateral; C–F, antenna, stages 1–4; G,H, maxillule and maxilla, stages 1; I,J, maxillule and maxilla, stage 4; K–N, telson, dorsal, stages 1–4. Scales indicate 0.1 mm.

Scaphognathite has a rounded proximal end provided with 3 setae, and another 5 setae on the outer margin. Maxillipeds bear 6 swimming setae.

Stage 3. From spine to spine: 2.10-2.58 mm. in 12 specimens.

Abdomen is of 6 somites plus telson. Telson is now slightly more than twice as long as wide, and length of fork is 2.5 times the rest of telson. Outer spine 1 is much smaller than spine 3. Inner seta 1 reaches 2/5 the length of fork, slightly exceeding tip of outer spine 3. Antennal endopod is beginning. Maxillule has a simple seta on outer margin of coxa in addition to the feathered seta of basis. Scaphognathite is fringed with 14 setae. Rudiments of legs are free. Maxillipeds bear 8 swimming setae.

Stage 4. From spine to spine: 3.3-3.5 mm. in 4 specimens.

Telson is 2.5 times as long as wide, and fork is slightly more than twice as long as the rest of telson. There are 3 extra inner setae. Postero-lateral spines on abdominal somite 3 are 4/5 as long as somite 4. Antennal endopod is slightly longer than exopod less spines. Rudiments of maxilliped 3 and legs are large but still unsegmented and covered by carapace. Rudiments of pleopods are free. Maxillipeds bear 10-11 swimming setae.

Remarks Judging from development of antennal endopod, legs and pleopods stage 4 is likely to be penultimate or antpenultimate zoeal stage. YATSUZUKA (1952, 1957) recognized 6 zoeal stages when he reared this crab from egg in the laboratory.

AIKAWA (1937) described the first zoea of this crab hatched from eggs as *Charybdis 6-dentata* HERBST. In his first zoea five pairs of leg buds are already present and sides of abdominal somite 5 are rounded behind. On the other hand YATSUZUKA(1952, 1957) observed leg rudiments appearing in later stages, and sides of abdominal somite 5 being produced behind into distinct spines. Our results confirmed YATSUZUKA's observations.

Portunus hastatoides FABRICIUS

The "HIME GAZAMI" is fairly common in the regular trawl catches in the Seto Inland Sea, though useless commercially owing to its small size attaining only 45 mm. across carapace. It ranges from Tokyo Bay to Kyushu in Japan, further extending widely in tropical Indo-West Pacific (SAKAI, 1939). Any of the larval stages are not known before.

Berried crabs were separated from trawl catches off Onomichi on July 15, 1974, and their eggs hatched out on July 29. Unfortunately, every attempts to rear the zoeae with similar method as in *Ch. japonica* failed, and none of them reached stage 2.

ZOEA (Fig. 2)

All the spines present on carapace. Rostral spine is almost straight and smooth, and is shorter than carapace. Dorsal spine curves without terminal hook, and is longer than rostral spine but slightly shorter than carapace. Lateral

spines are short. Eyes are very large.

There are lateral hooks on abdominal somites 2 and 3, and postero-lateral spines on somites 3-5. Postero-lateral spines on somite 3 are longer than those on somite 4. Telson is slender and forked, with 3 outer spines of which spines 1 and 3 are spinous while spine 2 is minute and hair-like. Spine 1 is longer than spine 3, and its insertion is level with that of inner seta 1. Spine 3 bends inward distally in stage 1. Inner seta 1 is somewhat less than 1/2 as long as fork, slightly exceeding tip of outer spine 3.



Fig. 2. *Portunus hastatoides*: zoeal stage 1. A, lateral view; B, antenna; C, telson, dorsal. Scales indicate 0.1 mm.

Antenna is nearly as long as rostral spine in stage 1. Exopod is of moderate length ending in a short spine with an apical inner spine which is as long as the rest of exopod including terminal spine. Structure of mouth parts and maxillipeds are very like *Charybdis japonica*.

Stage 1. From spine to spine: 0.90-1.02 mm. in 15 specimens.

Eyes are sessile. Abdomen is of 5 somites plus telson. Rostral spine is about 2/3 as long as carapace, while dorsal spine is slightly shorter than the latter.

Telson is somewhat less than twice as long as wide. Fork is 1/2 times longer than the rest of telson. There are 3+3 inner setae. Antenna has no endopod. Exopod less spines is about 1/5 as long as spinous process. Maxillule has no outer setae. Scaphognathite bears 4 setae on outer margin, ending proximally in a large feathered seta. Maxillipeds bear 4 swimming setae. There are rudiments of maxilliped 3, but no legs or pleopods.

DISCUSSION

Zoeae of the two species described here are much more like than different each other. Every essential characters are common to both. They differ, however, in certain minor details as are summarized in the following table.

Distinguishing characters between zoeae of Charybdis japonica and Portunus hastatoides

Characters	*Charybdis japonica*	*Portunus hastatoides*
Rostral spine	Not much shorter than carapace	Much shorter than carapace
Antenna	Much shorter than rostral spine	As long as rostral spine
Postero-lateral spines of abdominal somite 3	Shorter than those of somite 4	Longer than those of somite 4
Outer spines on telson	Spine 1 is as long as or shorter than spine 3. Its insertion is behind to that of inner seta 1.	Spine 1 is longer than spine 3. Its insertion is level with that of inner seta 1.

Among these differences, those in outer spines of telson may be taken as generic between *Charybdis* and *Portunus* since the similar differences are consistently observed between several members of the both genera (KURATA, 1975).

SUMMARY

Zoeal stages 1-4 of *Charybdis japonica* and stage 1 of *Portunus hastatoides* reared from egg in the labortaory are described in detail. Generic difference between the two genera may be seen in the armature of telson, while specific differences are found in relative length of antenna, of spines on carapace, and of postero-leteral spines on abdominal somites 3 and 4.

References

AIKAWA, H. (1929) : On larval forms of some Brachyura. *Rec. Oceanogr. Works Jap.* 2, 17—55.

AIKAWA, H. (1937) : Further notes on Brachyuran larvae. *Rec. Oceanogr. Works Jap.* 9, 87—162.

KURATA, H. (1975) : Larvae of Decapoda Brachyura of Arasaki, Sagami Bay-V. The swimming crabs of the subfamily Portuninae. *Bull. Nansei Reg. Fish. Res. Lab.* 8, 39—65.

LEBOUR, M. V. (1928) : The larval stages of the Plymouth Brachyura. *Proc. Zool. Soc. London* 1928, 473—560, 16 pls.

OSHIMA, S. (1938) : Biological and fishery researches in Japanese blue crab (*Portunus trituberculatus* MIERS). *Jour. Imp. Fish. Exp. Station* 9, 208-212, Pls. 2-5. (in Japanese with English summary)

SAKAI, T. (1939) : Studies on the crabs of Japan IV. Brachygnatha, Brachyrhncha. Yokendo, Tokyo, pp. 365-741, Pls. 42-111.

YATSUZUKA, K.(1952) : The metamorphosis and growth of the larvae of *Charybdis japonica* A. MILNE EEDWARD. *Bull. Jap. Soc. Sci. Fish.* 17 (11), 353-358 (in Japanese with English summary).

YATSUZUKA, K. (1957) : Study of Brachyuran zoea, artificial rearing and development. *Suisangaku Shusei*, 571-590, Uuiversity of Tokyo press. (in Japanese)

YATSUZUKA, K. (1962) : Studies on the artificial rearing of the larval Brachyura, especially of the larval blue-crab, *Neptunus pelagicus* LINNAEUS. *Rep. Usa Mar. Biol. Station, Kochi Univ.* 9 (1), 1-88. (in Japanese with English summary)

イシガニとヒメガザミの飼育幼生について

倉田　博・仁科重巳

瀬戸内海において圧倒的に優勢なガザミ類であるイシガニとヒメガザミとについて、抱卵親ガニからふ化した幼生を飼育して、ゾエア期の形態的特徴を明らかにした。両種のゾエアは、すべての基本的な特徴に関して、違いよりも類似の方がはるかに顕著である。主な相違点は頭胸甲の棘、第2触角、腹節後側棘などの相対的な長さのほか、尾節第1側棘の縮少傾向に認められる。最後に掲げた相違点は、ほかの種に関する知見と合せて判断すると、恐らく *Charybdis* 属と *Portunus* 属との違いを示すものと考えられる。

Bull. Nansei Reg. Fish. Res. Lab. (8) 29~38 (1975)

The Larval Stages of the Swimming Crabs, *Portunus pelagicus* and *P. sanguinolentus* Reared in the Laboratory

Hiroshi KURATA and Tadayasu MIDORIKAWA*

Certain of the members of the swimming crabs support fairly important local fisheries in the Seto Inland Sea and increasing attempts have been undertaken in recent years to improve fishery resources in the sea by releasing a large number of young crabs reared from egg in the hatcheries. Identification of planktonic larval crabs is of prime importance to study in nature early life histories of these crabs and to develop suitable releasing methods which guarantee high rates of survival of seed crabs introduced in the sea.

This paper presents detailed descriptions and line drawings of the larvae of *P. pelagicus* and *P. sanguinolentus* which are very common in the coastal and offshore waters of Wakayama Prefecture.

Berried crabs were obtained from regular commercial catches by local fishermen and were kept in an aerated plastic 0.5 ton aquarium until eggs hatched out. The newly hatched zoeae were transferred into rearing tanks containing filtered sea water and unicellular green algae, *Chlorella* sp., at a medium concentration. Zoeae were fed with rotifers, *Brachionus* sp., and newly hatched *Artemia* nauplii in succession. Samples were taken at intervals, fixed and preserved in 5% sea water formaline for the later examinations. Measurements of the larvae were taken according to KURATA (1975).

Portunus pelagicus (Linnaeus)

The "TAIWAN GAZAMI" ranges from Sagami Bay to Kyushu in Japan, further extending widely in offshore waters of tropical Indo-West Pacific and East Africa. (SAKAI, 1939). This is the most important commercial crabs in Wakayama Prefecture keeping the highest prices in the local markets (300-700 yen per crab in 1974). It is somewhat smaller than the estuarine relative, *P. trituberculatus*, attaining about 170 mm. across carapace and 400 grams in wet weight, and prefers higher temperatures and higher salinities than does the latter.

Berried crabs were obtained in August, 1974 from the gill-net catches from 5-6 meter deep, and the hatched larvae were reared in 7 ton concrete tanks. Some of them survived beyond metamorphosis. Four zoeal stages and one megalopa were recognized.

Received: August 5, 1975. Contribution No.49 from the Nansei Regional Fisheries Research Laboratory
※ Fishery Propagation Station, Wakayama Prefecture

ZOEA (Fig. 1)

Carapace has all the spines, which are all smooth. Rostral spine is long and almost straight. Dorsal spine curves, ending in a hook. It is distinctly longer than carapace as well as rostral spine in all stages. Lateral spines are less than 1/4 as long as carapace. Eyes are large, maximum diameter of cornea being almost 1/2 the length of carapace in early stages. Ventral margin of carapace is denticulated, and, in later stages, is fringed with sparse setae. There is an inconspicuous dorsal knob on the carapace above stomach.

Abdomen is much shorter than distance from spine to spine. There are lateral hooks on somites 2 and 3, and postero-lateral spines on somites 3-5. These are distinct in all stages. Postero-lateral spines of somite 3 are somewhat longer than those of somite 4.

Telson is slender and typically forked, with 2 outer spines, lacking the second. Forks are smooth. Outer spines 1 and 3 are spinous. Spine 1 is almost as long as or slightly longer than spine 3, and its insertion is almost level with that of inner seta 1 in early stages, but moves behind the latter in later stages. Spine 3 is inserted about 1/3 way down on the fork and inner dorsal in position, bending inward distally in early stages. Inner setae are somewhat less than 1/2 the length of fork, seta 1 reaching only slightly behind tip of outer spine 3. There is a pair of extra inner setae inside in later stages.

Antennule in all but the last stage is simple and unjointed. It is jointed and biramous in the last stage. Antenna is much shorter than rostral spine with two rows of spinules along spinous proccess. The spinules, in later stages, are arranged in more than two rows at proximal portion. Exopod is about 1/3 as long as spinous process ending in a short spine with an apical inner spine which is almost as long as the rest of exopod less terminal spine. Endopod appears from stage 3.

Mandible is well developed with a palp in the last stage. Endopod of maxillule is of 2 segments with 1 and 6 setae on proximal and distal segment respectively. A feathered seta and a simple seta is present on outer edge of basis and coxa respectively in later stages. Endopod of maxilla is unsegmented but bilobed with 6 setae in 3 pairs of which the terminal pair tends to be suppressed. Endopod of maxilliped 1 is of 5 segments and that of maxilliped 2 is of 3 segments. Maxilliped 3 is seen as minute rudiments from stage 1, while legs become free from stage 2.

Stage 1. From spine to spine : 1.38-1.50 mm. in 20 specimens.

Eyes are sessile. Rostral spine is about 4/5 as long as carapace, while dorsal spine is somewhat longer than the latter. Abdomen is of 5 somites plus telson. Telson is twice as long as wide. Fork is somewhat longer than the rest of telson. There are 3+3 inner setae. Postero-lateral spines on abdominal somite 3 are about 1/3 as long as somite 4. Antenna is 5/6 as long as rostral spine without endopod. Maxillipeds bear 4 swimming setae.

Stage 2. From spine to spine : 1.92-2.10 mm. 15 specimens.

Eyes are stalked. Telson is 1/3 times more than twice as long as wide, with a



Fig. 1. *Portunus pelagicus*: zoeal stages 1–4. A, stage 1, lateral; B, stage 4, lateral; C–F, antenna, stages 1–4; G,H, stage 1, maxillule and maxilla; I,J, stage 4, maxillule and maxilla; K–N, telson, dorsal, stages 1–4. Scales indicate 0.1 mm.

pair of extra inner setae inside. Fork is 1/4 times longer than the rest of telson. Antenna is 3/4 as long as rostral spine with a short endopod. Leg buds are free but no pleopods are present. Maxillipeds bear 8, instead of 6, swimming setae.

Stage 3. From spine to spine : 2.88–3.12mm. in 5 specimens.

Rostral spine is 1/5 times longer than carapace. Abdominal somite 6 is segmented off from telson, which is now slightly more than twice as long as wide. Outer spine 1 moves behind insertion of inner seta 1. Postero-lateral spines of abdominal somite 3 are about 1/3 as long as somite 4. Antenna is about 2/3 as long as rostral spine, endopod is somewhat longer than exopod less spines. Pleopods appear, simple and unjointed, and are about 1/2 as long as their respective somite. Maxillipeds bear 10–11 swimming setae.

Stage 4. From spine to spine : 3.48–3.55mm. in 3 specimens.

Postero-lateral spines of abdominal somite 3 are 2/3 as long as somite 4. Telson is very selnder, much more than twice as long as wide. There is still a pair of extra inner setae. Antennule is jointed and biramous with 2 groups of aesthetascs on outer flagellum. Antenna is about 1/2 as long as rostral spine. Endopod is about 3/4 as long as spinous process with a basal articulation. Maxilliped 3 and legs are very large and more or less jointed, emerging from carapace cover. Maxillipeds bear 12–13 swimming setae. Pleopods are nearly as long as their respective somite.

MEGALOPA (Fig. 2)

Total length ranges 3.8–4.0mm. and carapace length 2.1–2.4mm. Carapace has no conspicuous protuberances or dorsal spines, but has a pointed rostrum sticking out foreward almost horizontally. The rostral spine is slightly shorter than the rest of rostrum. Rostrum as a whole constitutes somewhat less than 1/2 the length of carapace and is almost 1/2 as wide as carapace. Abdomen is of 6 somites plus telson and is about 2/3 as long as carapace. Sides of somite 5 stick out behind into a pair of lateral spines, reaching to proximal 1/3 of telson. Telson is almost as long as wide. There are well developed, biramous pleopods on abdominal somites 2–5, and uniramous uropod on somite 6 bearing 9–10 setae on exopod and with or without a seta on protopod.

Antenna is consisted of a protopod of 4 segments and a flagellum of 8 segments, exceeding tip of rostrum by its distal 3–4 segments. Segment 5 of flagellum has a pair of long setae at distal end. Mouth parts assume general characters of the genus (Kurata, 1975).

Leg 1 has a hook-shaped spine on ventral edge of ischium and on antero-ventral edge of carpus. Palm is 1/2 times longer than wide. Fingers are almost as long as palm with 4 teeth each along inner edges of movable and immovable ones. Tip of fingers deeply crosses each other when chela is closed. Leg 2 has a spine on ventral edge of coxa. There is a large sternal spine (cornua) each side at the base of leg 4, sticking out behind and reaching slightly beyond hind end of abdominal somite 2. Last segment of leg 5 is paddle-shaped, ending in a short spine with 2 feathered setae and 6 feelers, of which two are saw like, along

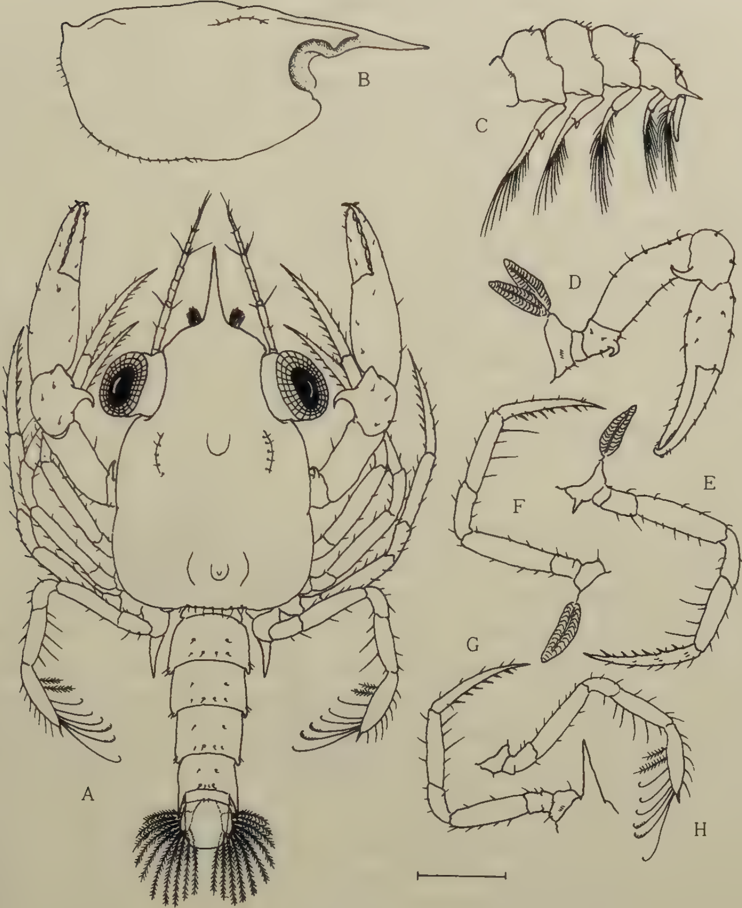


Fig. 2. *Portunus pelagicus* : megalopa. A, dorsal view ; B, carapace, lateral ; C, abdomen, lateral ; D–H, legs 1–5. Scale indicates 0.5 mm.

ventral margin.

There is 1 long mastigobranch with filamentous setae on maxillipeds 1 and 3, 2 arthrobranchs each on maxillipeds 2, 3 and leg 1, and an arthrobranch on legs 2 and 3. Gill formula is thus completed as in the adult except a mastigobranch on maxilliped 2.

Remarks Zoeae and megalopa of this crab reared from egg in the laboratory have been briefly described and figured by YATSUZUKA (1957, 1962). He found that they changed into megalopa from either stage 4 or 5. Those reared under favourable conditions usually changed into megalopa from stage 4.

Zoea of *P. pelagicus* is unique among Portuninae in bearing 8, instead of 6, swimming setae in stage 2. This is also confirmed by YATSUZUKA (1962). The fact, together with the character having very long rostral and dorsal spines on carapace, seems to be an adaptation of the zoea keeping up the surface layers.

Portunus sanguinolentus (Herbst)

The "JANOME GAZAMI" is very common in oceanic littoral areas from Tokyo Bay to Kyushu and elsewhere in the tropical Indo-West Pacific. It is much more abundant than *P. pelagicus* in Wakayama Prefecture. Commercially, however, it is less important than the latter owing to its smaller size attaining only 130 mm. across carapace.

At Arasaki, Sagami Bay, berried crabs are found as early as June, while in Harima Nada, Seto Inland Sea, period of egg carriage is limited to the later half of the year, August-December (HAMADA *et al*, 1975).

Newly hatched zoeae were obtained from berried crabs separated in August, 1974 from regular trawl catches in Tanabe Bay, Wakayama Prefecture. They were reared in an aerated 0.5 ton plastic aquarium by the similar method as in *P. pelagicus*. Unfortunately, however, they did not live beyond stage 4.

ZOEA (Fig. 3)

Zoea is very like *P. pelagicus* in essential characters, but differs from it in smaller size and rudimentary antennal exopod. Rostral spine is shorter than carapace in all stages. Dorsal spine curves without terminal hook, and is almost as long as carapace. Lateral spines are 1/3-1/4 the length of rostral spine.

Telson is forked and bears 3 outer spines. Spines 1 and 3 are large and spinous in all stages, while spine 2 is minute and hair-like disappearing in later stages. Spine 1 is much larger than spine 3, and its insertion is almost level with that of inner seta 1. Spine 3 is at about proximal 1/4 of fork and bends inward distally. Inner seta 1 is about 2/3 as long as fork, well exceeding tip of outer spine 3. There is a pair of extra inner setae in later stages. Telson fork is rather short. It is nearly as long as the rest of telson and abdominal somite 6 combined in early stages but distinctly shorter than the latter in later stages.

Antenna is more or less shorter than rostral spine with two rows of spinules along spinous process. Exopod is very small, less than 1/7 as long as spinous process, ending in a short spine which is as long as the rest of exopod. Apical inner spine is about twice as long as exopod including terminal spine. Endopod of maxillule is of 2 segments with 6 aetae on distal segment. No seta is present on proximal one. Endopod of maxilla is unsegmented but bilobed with 6 setae in 3 pairs, of which the terminal pair tends to be suppressed. Endopod of maxilliped 1 is of 5 segments and that of maxilliped 2 is of 3 segments.

Stage 1. From spine to spine : 0.81-0.93mm. in 15 specimens.

Eyes are sessile. Maximum diameter of cornea much exceeds 1/2 the length of carapace. Rostral spine is about 2/3 as long as carapace. Abdomen is of 5 somites plus telson. Postero-lateral spines on abdominal somites 3-5 are very short with minute accessory denticles dorsally. Telson is 3/4 times longer than wide. Fork is almost as long as the rest of telson. There are 3+3 inner setae. Outer spine 2 is minute but distinct in all specimens examined. There are neither antennal endopod nor legs nor pleopods. Maxillipeds bear 4 swimming setae.

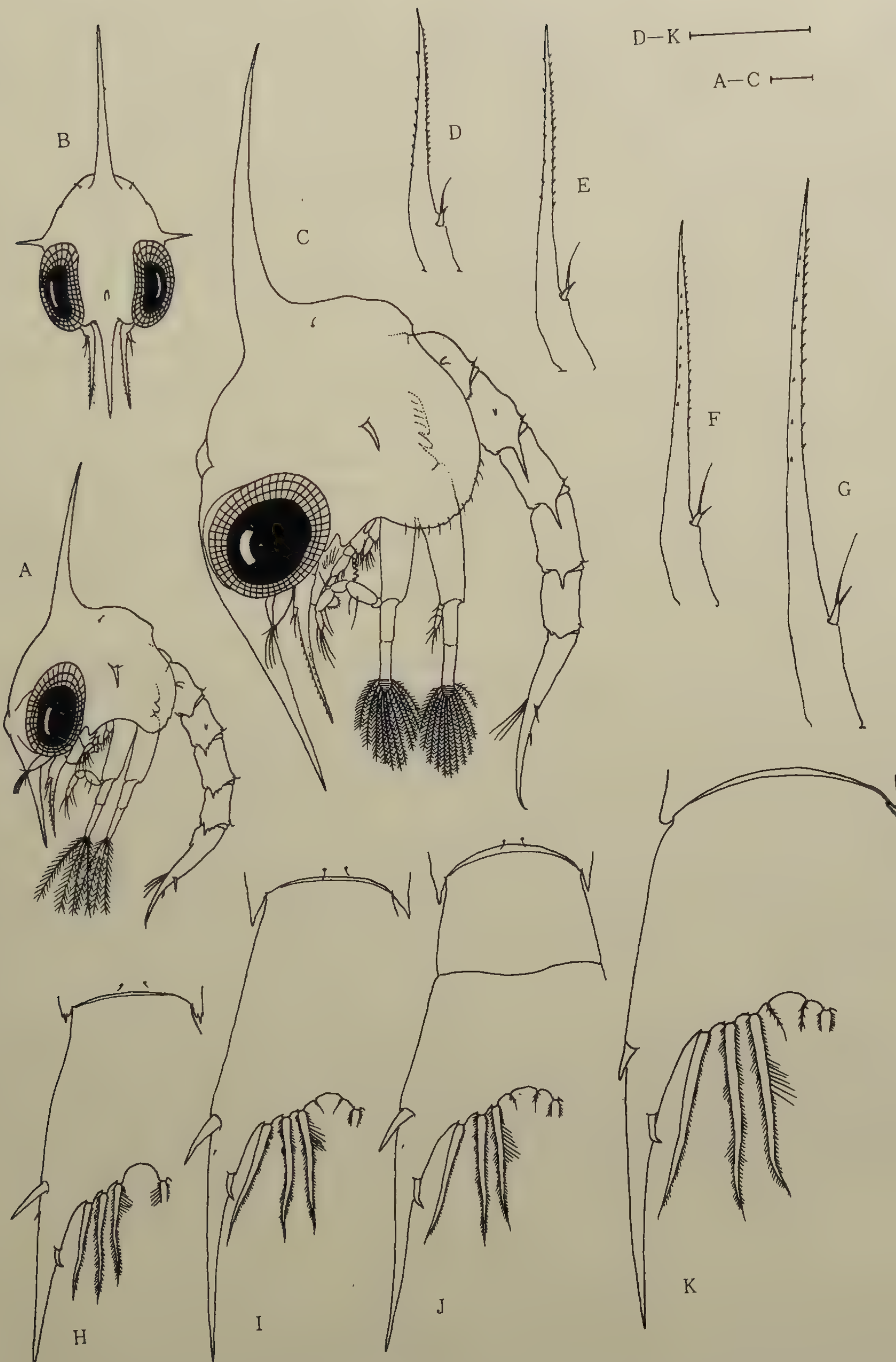


Fig. 3. *Portunus sanguinolentus*: zoeal stages 1–4. A, stage 1, lateral; B, the same, carapace, dorsal; C, stage 4, lateral; D–G, antenna, stages 1–4; H–K, telson, dorsal, stages 1–4. Scales indicate 0.1 mm.

Stage 2. From spine to spine : 1.05–1.14mm. in 15 specimens.

Eyes are stalked. Telson is twice as long as wide. Fork is only 1/6 times longer than the rest of telson. There is a pair of extra inner setae. Postero-lateral spines on abdominal somites 3–5 are simple without accessory spines, and are about 1/3 as long as their succeding somites. Maxillipeds bear 6 swimming setae.

Stage 3. From spine to spine : 1.38–1.68mm. in 6 specimens.

Abdomen is of 6 somites plus telson. Telson is now somewhat less than 1/2 times longer than wide. Fork is 1/2 times longer than the rest of telson but somewhat shorter than combined length of somite 6 and the latter. Insertion of outer spine 1 is almost level with or slightly anterior to that of inner seta 1. Inner seta 1 reaches about 2/3 the length of fork. Antenna has no endopod and is about 2/3 as long as rostral spine. Maxillipeds bear 8 swimming setae.

Stage 4. From spine to spine : 1.82–1.91mm. in 2 specimens.

Telson fork is about 1/2 times longer than the rest of telson, and is nearly equals to width of telson. Outer spine 1 is slightly behind to inner seta 1 at insertion. Outer spine 2 disappears in all the specimens examined. Postero-lateral spines on abdominal somite 3 reach to about 2/3 the length of somite 4. Rudiments of legs are still folded. There are no antennal endopod or pleopods. Maxillipeds bear 10–11 swimming setae.

Remarks Zoea of *P. sanguinolentus* is quite outstanding among Portuninae and is readily distinguished from the other known species of Portuninae by its rudimentary antennal exopod. Judging from the state of development in stage 4 zoea, 2 more stages at least should be passed before reaching megalopa.

RAJA BAI NAIDU (1955) described first zoea hatched from egg. Her first zoea is somewhat smaller than the present materials measuring only 0.75 mm. from spine to spine. She states and figures that the antennal exopod is spinous as a whole with a short seta at about half its length on the outer edge. In the present materials, however, antennal exopod has a general character of the genus, ending in a short spine with an apical inner spine. Her observation on the setation of endopods of maxillule and maxilla is also not entirely correct. These endopods, in the present materials, assume the character of the genus bearing 6 setae instead of 4 as she described. In compiling zoeal characters of the known species of *Portunus,* she cites zoea of *P. trituberculatus* from AIKAWA (1929) who, unfortunately, overlooked lateral spines on carapace, though revised in a later paper (AIKAWA, 1937).

DISCUSSION

Zoeae of the two species described here differ each other in many minor details as summarized in the following table, though resembling in every essentials.

Distinguishing characters between zoeae of P. pelagicus and P. sanguinolentus

Characters	*P. pelagicus*	*P. sanguinolentus*
Dorsal spine on carapace	Longer than carapace ending in a hook	As long as carapace without terminal hook
Rostral spine on carapace	Longer than carapace except in stage 1	Shorter than carapace in all stages.
Antennal exopod	Moderately long	Very short
Telson	Twice or more as long as wide	Not more than twice as long as wide
Inner setae of telson	Only slightly exceed hind end of outer spine 3	Well exceed hind end of outer spine 3
Outer spine of telson	Spine 1 is not much longer than spine 3	Spine 1 is much longer than spine 3

Characters of zoea which are essential and common to both are the presence of all the spines on carapace, of lateral hooks on abdominal somites 2 and 3, of postero-lateral spines on somites 3-5, and of 3 outer spines on telson including rudimentary second. Basic characters of antenna which are common to both seem to be most important since this is quite consistent among Portuninae so far known and is very usefull to distinguish them as a whole from the other groups of Brachyura. Comparison of characters between zoeae of the two species clearly indicates that we should refer to the minor details instead of essential characters as AIKAWA (1929, 1937) did in order to distinguish between the species of Portuninae.

SUMMARY

Zoea stages 1-4 and megalopa of *Portunus pelagicus* and zoea stages 1-4 of *P. sanguinolentus* were described and figured in detail based on the materials reared from egg in the laboratory. Larvae of *P. pelagicus* pass through 4 zoeal stages and one megalopa before changing into crab, while in *P. sanguinolentus* more than 4, probably 6, stages are assumed in the zoea. Zoeae of the two species are very like in every essentials but differ in minor details.

References

HAMADA, T., I.TAKAHASHI, Y.MATSUDA and Y. MATSUI (1975) : Notes on the egg carrying period of the swimming crabs in the eastern Seto Inland Sea. Summary Report for 1971-1974, The Seto Inland Sea Fish Farming Project (GAZAMI team), 4-6. (in Japanese)

KURATA, H. (1975) : Larvae of Decapoda Brachyura of Arasaki, Sagami Bay-V. The swimming

crabs of the subfamily Portuninae. *Bull. Nansei Reg. Fish. Res. Lab.* **8**, 39-65.
RAJA BAI NAIDU, K.G. (1955) : The early development of *Scylla serrata* (Forsk.) de Haan and *Neptunus sanguinolentus* (Herbst). *Ind. Jour. Fish.* 2, 67-76.
SAKAI, T. (1939) : Studies on the crabs of Japan. IV. Brachygnatha, Brachyrhyncha. Yokendo, Tokyo, pp. 365-741, Pls. 42-111.
YATSUZUKA, K. (1952) : The metamorphosis and growth of the larvae of *Charybdis japonica* A. Milne Edward. *Bull. Jap. Soc. Sci. Fish.* 17 (11), 353-358. (in Japanese with English summary)
YATSUZUKA, K. (1957) : Study of Brachyuran zoea, artificial rearing and development. *Suisangaku Syusei*, 571-590. Univ. of Tokyo Press, Tokyo. (in Japanese)

タイワンガザミとジャノメガザミの飼育幼生について

倉田　博・翠川忠康*

ガザミ類幼生の同定は，プランクトン期の生活史研究に不可欠であるが，この点に関する従来の知見は極めて不充分である。本報告では，タイワンガザミのゾエアとメガロパおよびジャノメガザミのゾエアについて，ほかのカニ類幼生との識別を目的として，外部形態の詳細を記載し図解した。観察材料は抱卵親ガニからふ化した幼生を実験室で飼育したものである。

タイワンガザミの幼生期にはゾエア4期とメガロパ1期とを認めた。ジャノメガザミは第4期ゾエアまで飼育したが，歩脚や腹肢の発達から判断すると，メガロパまでにさらに少くとも2期を経過するだろうと推測した。

両種のゾエアはすべての基本的な特徴において互いに一致する。主な違いは体の大きさのほか頭胸甲の棘，第2触角外肢，尾節の形と棘などの相対的な長さに認められる。いわゆる基本的な特徴はガザミ類幼生を一括してほかのカニ類幼生から識別するためには非常に有用であるが，ガザミ類相互間の識別にはほとんど役に立たない。恐らく，種，属，科など分類体系の水準に応じて，形態分化は違った部分に現われるからだと考えられる。

（註） * 和歌山県水産増殖試験場

Bull. Nansei Reg. Fish. Res. Lab. (8) 39～65 (1975)

Larvae of Decapoda Brachyura of Arasaki, Sagami Bay-V. The Swimming Crabs of Subfamily Portuninae

HIROSHI KURATA

The swimming crab is one of the most dominant group of crabs from low tide mark to outer littoral areas in Japan and elsewhere in the warm water regions. A variety of species live among sea weeds on rocky shores as well as on sand-mud flats in estuaries and offshores. Certain of the members support fairly important local fisheries in Japan along the Pacific, East China Sea and Japan Sea coasts.

The Japanese genera belonging to subfamily Portuninae are *Scylla* DE HAAN, *Portunus* WEBER, *Charybdis* DE HAAN, *Thalamita* LATEREILLE and *Lupocyclus* ADAMS & WHITE (SAKAI, 1939). Certain of the larval stages have already been described by AIKAWA (1929, 1937), OSHIMA (1938), YATSUZUKA(1952, 1957), RAJA ABI NAIDU (1955) and KURATA and OMI (1969). However, diagnostic characters which enable one to identify the species among Portuninae are still far from full understanding. Thus, YATSUZUKA (1957) was unable to distinguish zoea of *Portunus trituberculatus* from that of *P. pelagicus* or of *Charybdis japonica* by the basic diagnostic characters proposed by AIKAWA (1929, 1937). Indeed, zoeae of members of Portuninae are so much alike (LEBOUR, 1928) that the identification of species is almost impossible without referring to every available minor differences. The identification of larval crabs in the plankton is essential for the study of their ecology in nature.

This report presents the result of survey of all the larval crabs of subfamily Portuninae that the present author carried out at Arasaki Station of the Tokai Regional Fisheries Research Laboratory. A single report has already been published on this subject on *Charybdis acuta* (KURATA & OMI, 1969), and the remaining species belonging to *Portunus, Charybdis* and *Thalamita* are described here so far as they are known. A tentative key is also presented to genera and species for the known zoeae of Japanese Portuninae.

Materials and Methods

All the descriptions and drawings are taken from the specimens reared from egg in the laboratory except when otherwise stated. Coloration was observed in the first zoea. The berried crabs were obtained from commercial gill net catches and were kept in aerated aquaria of various sizes until eggs hatched out. The newly hatched larvae were transferred and reared in glass bowls of about 500 ml. capacity. About 20 larvae were held per bowl. The rearing water was

Received: August 5,1975. Contribution No. 50 from the Nansei Regional Fisheries Reasearch Laboratory

partly renewed every day. The early stage zoeae were fed on rotifers, *Brachionus* sp., cultured separately in a large tank, and the later stage zoeae on newly hatched *Artemia* nauplii. Small pieces of the mantle of the short-necked clam, *Tapes philippinarum*, were used to feed the megalopae.

Specimens of each molting stage were separated from the rearing stock, fixed and preserved in 5 % sea water formaline for the later examination. No attempt has been made to collect prezoeae. Measurements were taken perpendicular under a microscope with an ocular micrometer for zoea:

1. Length from spine to spine: from tip of rostral spine to tip or, when bending in a hook, terminal outer edge of dorsal spine,
2. Length of carapace: from the anterior edge of eyestalk to the posterior edge of carapace at the base of dorsal spine,
3. Length of telson: from the joint with the last abdominal somite to tip of telson fork, somite 6 being included when it is fused with telson,
4. Width of telson: distance between outer edges at the level of insertion of inner seta 1,
5. Length of telson fork: from the insertion of inner seta 1 to tip of fork,

and for megalopa:

1. Carapace length: from tip of rostrum to posterior margin along middorsal line,
2. Total length: from tip of rostrum to hind end of telson.

As to the armatures of telson in zoea, outer spines and inner setae are separately numbered from anterior backward or from outside inward. One or two of the outer spines may be absent from stage 1 or disapper in later stages. Nevertheless, the spine numbers are assigned as if they were in the assumed primitive form with 3 outer spines and 3 inner setae in addition to the fork each side.

Genus *Portunus* Weber

Among the genus *Portunus* five species are very common in Japanese waters. They are *P. trituberculatus, P. gladiator, P. pelagicus, P. sanguinolentus* and *P. hastatoides*. The larval stages of the last three species are described elsewhere (Kurata & Midorikawa, 1975; Kurata & Nishina, 1975), and those of the remaining two species are described here. Aikawa (1929, 1937), Oshima (1938), Raja Bai Naidu (1955) and Yatsuzuka (1957) described certain of the larval stages of *P. trituberculatus, P. pelagicus* and *P. sanguinolentus*. Their descriptions are, however, too inadequate to tell them apart with any certainty.

The general characters of *Portunus* as evidenced by the above five species may be summarized as follows.

Zoea comprises 4, 5 or more stages. Number of zoeal stages may vary between different species and also even within the same species depending on the conditions of rearing such as temperatures and available foods. Zoea is rather poorly colored with diffused yellow pigment and black chromatophores. The

black chromatophores are consistent over vicera extending along intestine as far back as abdominal somite 2, and ventrally to hind end of abdominal somites 2-5.

Carapace has rostral, dorsal and a pair of lateral spines. All the spines are smooth. Rostral spine is almost straight. Dorsal spine curves posteriorly with or without terminal hook, and is longer than rostral spine. Lateral spines are short. Ventral margin of carapace is somewhat irregularly denticulated and, in later stages, fringed with sparse setae. Eyes are very large. There is an inconspicuous anterior dorsal knob above stomach.

Abdomen is of 5 somites plus telson in stages 1 and 2, and is 6 somites plus telson from stage 3. Abdominal somites 2 and 3 bear lateral hooks in all stages. These are used to fasten free edge of carapace each side when abdomen is curled in under the body. Those on somite 2 are larger and more hook-like than those of somite 3. Posterolateral margin of somite 2 is produced into a small prominance with small denticles. Somites 3-5 have postero-lateral spines which are distinct from stage 1 and become prominent in later stages.

Telson assumes typical form with slender and smooth forks and 3 or 2 outer spines. Spine 1 is on or near the outer lateral edge of fork and its insertion is level with that of inner seta 1 in early stages at least. It is always larger than spine 3. Both are distinct and spinous in all stages, while spine 2 is minute and hair-like in stage 1 disappearing in later stages, or lacking from stage 1 in some species. Spine 3 is on the inner-dorsal edge bending inward distally in early stages. Its insertion is more or less behind tip of spine 1. There are 3+3 inner setae in stage 1, and 2-3 extra setae inside in later stages. Inner seta 3 bears several long setules along the inner edge.

Antennule in all but the last stage is simple and unjointed. It is jointed and biramous in the last stage. Antenna is of moderate length. Spinous process bears two rows of spinules along the outer lateral and the inner dorsal edges. Exopod ends in a hair-like spine with a long simple spine at apical inner edge, looking as if it were ending in two spines of different lengths. Endopod appears in later stages.

Mandible is well developed with a small palp in the last stage. Maxillule bears a feathered seta on the outer edge of basis from stage 2, and a simple seta on the outer edge of coxa from stage 4. Endopod is of 2 segments with one seta on the proximal segment and 6 setae in three pairs on distal segment. Maxilla consists of two bilobed endites, foliacious scaphognathite fringed with increasing number of feathered setae, and unjointed but bi- or tri-lobed endopod with 6 setae in three pairs, of which the terminal one tends to be more or less suppressed.

Endopod of maxilliped 1 is of 5 segments, and that of maxilliped 2 is of 3 segments. Number of swimming setae is 4, 6 and 8 in stages 1, 2 and 3 respectively, increasing somewhat irregularly in later stages. Trace of maxilliped 3 is present from stage 1, but the remaining limbs develop in later stages.

Megalopa is known in *P. trituberculatus* and *P. pelagicus*. Carapace has a square rostrum producing in the center into a long spine sticking out forward almost

horizontally. There is no other spines or prominent protuberances on carapace. Abdomen is of 6 somites plus telson. Somite 5 bears a pair of large, pointed postero-lateral spines, extending well beyond somite 6. Telson is almost as long as wide, slightly tapering behind.

Antennule is biramous with a protopod of 3 segments bending on itself, an outer flagellum of 4 segments with 3 tafts of aesthetascs, and an inner flagellum of one segment. Antenna extends well beyond the tip of rostrum and is composed of a protopod of 4 segments and a flagellum of 8 segments, of which segment 5 bears a pair of long setae at distal end.

Mandible is spoon-shaped. Cutting edge of the right is smooth, while that of the left is produced in the center into a small prominance. There is a palp of 2 segments bending inside the cutting edge. Maxillule has 2 well developed endites and an unsegmented endopod bending on itself with a few setae. Maxilla shows somewhat degenerated features compared to that in the last zoea in the setation of endites and of endopod which is now devoid of setae. Scaphognathite on the other hand, is greatly expanded and fringed with numerous setae. Endopod of maxilliped 1 is unsegmented with several short setae along terminal outer edge, and that of maxillipeds 2 and 3 is of 5 segments each with numerous spines and setae along the inner edge.

Leg 1 is chelate with a hook-like spine on ventral edge of ischium and antero-ventral edge of carpus. Fingers have 4 teeth each along cutting edge. Their tip deeply crosses each other when chela is closed. Leg 2 has a spine on ventral edge of coxa. There is a row of several prickly spines along the ventral edge of dactylii of legs 2-4 which are much longer than their propodii. Last segment of leg 5 is paddle shaped, ending in a spine, with 1 or 2 feathered setae and several feelers along ventral edge. The feelers are of two kinds. The one curves at the end with a row of very fine hairs along inner edge of curved portion, and the other curves likewise with a row of distinct teeth like a saw along inner edge of curved portion. There is a huge sternal spine each side at the base of leg 4, sticking out behind somewhat beyond hind end of abdominal somite 2.

There are well developed biramous pleopods on abdominal somites 2-5. Uropod is uniramous with or without one seta on protopod and more than 9 setae on exopod.

Portunus trituberculatus Miers

The "GAZAMI" is one of the most common edible crabs in Japan with very high market prices. It ranges from Hokkaido to Kyushu along Japanese Islands, further extending to Korea, Formosa and China. In 1972 the Japanese domestic production was 1, 466 metric tons including allied species, of which about 1/5 was landed from the Seto Inland Sea. The domestic production does not meet increasing demand in recent years and enhancing attempts have been undertaken with local successes to improve fishery production by releasing into the sea a

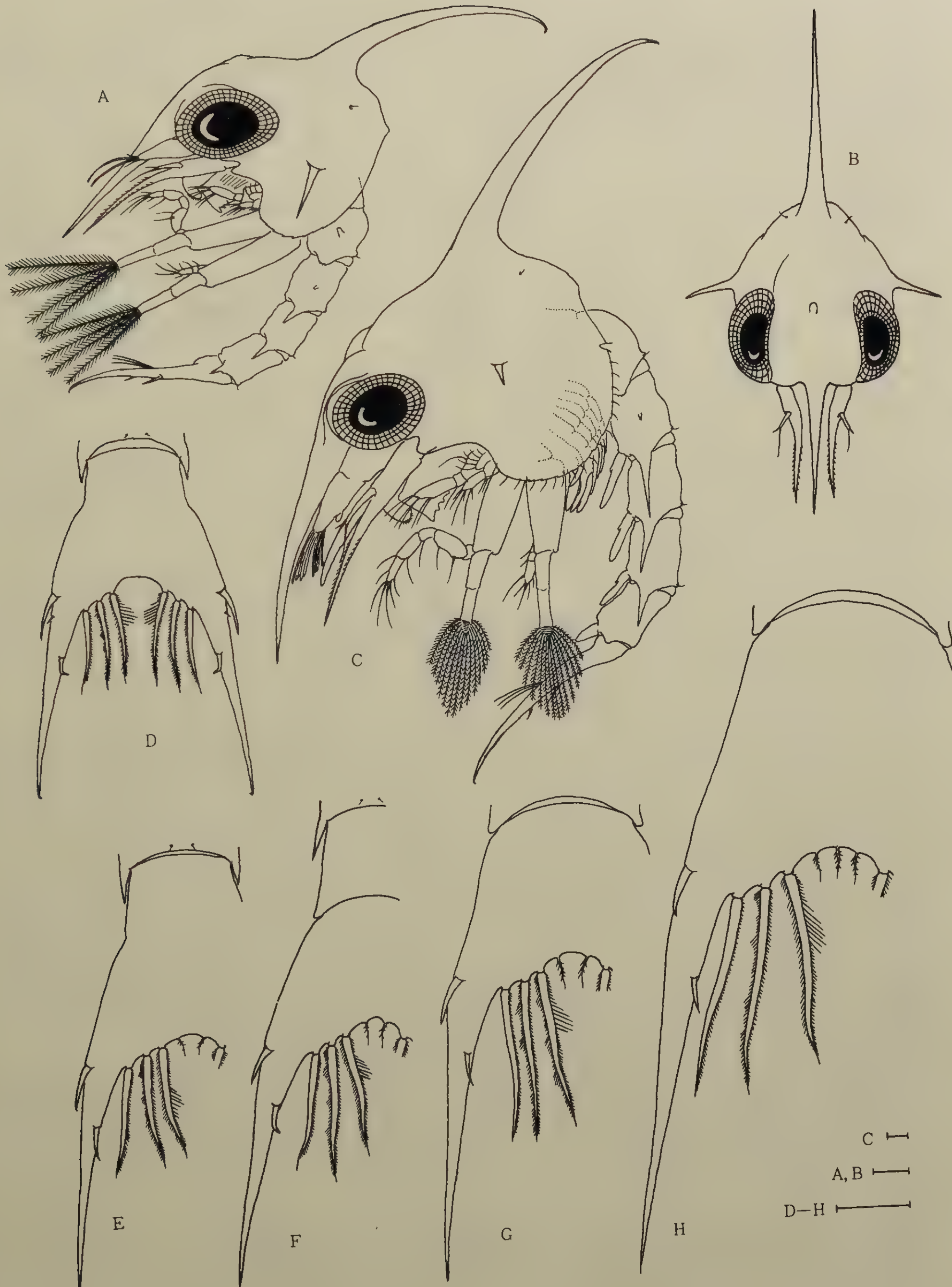


Fig. 1. *Portunus trituberculatus*, zoeal stages 1-5. A, stage 1, lateral; B, the same, carapace, dorsal; C, stage 5, lateral; D-H, telson, dorsal, stages 1-5. Scales indicate 0.1 mm.

large number of young crabs reared from eggs in the hatcheries.

Egg carrying crabs were seen from May to October. Early eggs are orange-red in color and about 0.31 mm. in diameter. Several batches of egg have been reared successfully up to crab stages.

ZOEA (Fig. 1; A-H: Fig. 2; A-K)

Zoea has following characters in addition to those of the genus. Rostral spine is shorter than carapace but dorsal spine is almost as long as or somewhat longer than the latter. Antenna is more or less shorter than rostral spine in all stages. Length of exopod less spines is somewhat more than 1/4 as long as spinous process, gradually increasing in relative length in later stages. Apical inner spine is about as long as exopod less terminal spine.

Postero-lateral spines on abdominal somites 3-5 never exceed hind end of their suceeding somites. The spines of somite 3 are longer than those of somite 4. Telson has 3 outer spines in stage 1 including minute spine 2 which disappears from stage 2. Inner setae are almost 1/2 as long as fork in all stages. Seta 1 reaches beyond tip of outer spine 3 by its distal about 1/5.

Five stages are recognized. It does not neccessarily follow, however, that they always molt five times to reach megalopa. YATSUZUKA (1957) showed that fast growing zoeae normally changed into megalopa after passing 4 molts, and stage 5 zoeae may occur when rearing conditions are nonoptimal.

Stage 1. From spine to spine: 1. 26-1.41 mm. in 10 specimens.

Eyes are sessile. Abdomen is of 5 somites plus telson. Telson is twice as long as wide. Fork is 1/3 times longer than the rest of telson. Antenna has no endopod. There is a small, uniramous rudiment of maxilliped 3, but no trace of legs or pleopods. Maxilllpeds bear 4 swimming setae.

Stage 2. From spine to spine: 1.62-1.77 mm. in 3 specimens.

Eyes are stalked. Telson fork is only slightly longer than the rest of telson. Outer spine 2 of telson disappears. There is a pair of extra inner setae inside. Antennl endopod is beginning. Rudiment of maxilliped 3 is biramous. Traces of leg buds are present. Maxillipeds bear 6 swimming setae.

Stage 3. From spine to spine: 2.10-2.40 mm. in 7 specimens.

Abdominal somite 6 is segmented off from telson. Telson is now 2/3 times longer than wide, and fork is somewhat less than twice as long as the rest of telson. Antennal endopod is shorter than exopod. Maxillipeds bear 8 swimming setae.

Stage 4. From spine to spine: 2.46-2.82 mm. in 7 specimens.

Postero-lateral spines on abdominal somite 3 almost reach hind end of somite 4. There are small pleopod buds. Telson is almost twice as long as wide. Fork is somewhat less than twice as long as the rest of telson. There are 3 extra inner setae. Antennal endopod is slightly longer than exopod less spines. Leg buds are large but still unjointed and covered by carapace. Maxillipeds bear 9-11



Fig. 2. *Portunus trituberculatus:* zoeal stages 1-5. A-E, antenna, stages 1-5; F-H, stage 5, mandibles, maxillule and maxilla; I-K, abdominal somites 2-5, stages 2-4. Scales indicate 0.1 mm.

swimming setae.

Stage 5. From spine to spine :3.25-3.60 mm. in 5 specimens.

Telson is slightly more than twice as long as wide. Fork is 1/2 times longer than the rest of telson. There are still 3 extra inner setae. Insertion of outer spine 1 is somewhat foreward to that of inner seta 1. Antennal endopod is about 3/4 as long as spinous process. Maxilliped 3 and legs are very large and more or less jointed, though not functional. Abdominal somites 2-5 bear long biramous pleopods, almost as long as respective somite. Maxillipeds bear 12-14 swimming setae.

MEGALOPA (Fig. 3 ; A-O)

Carapace length is 2.3-2.6 mm. (2.8-2.9 mm. in the specimens from the plankton) and total length is 4.1-4.5 mm. in 7 specimens. Rostrum is somewhat shorter than the rest of carapace and 1/2 as wide as the latter. Central spine is almost as long as or slightly shorter than the rest of rostrum. Postero-lateral spines on abdominal somite 5 reach to proximal 1/3 of telson.

Antennal flagellum exceeds tip of rostrum by its distal 3 or 4 segments. Palm of chela is 1/2 or 3/4 times longer than wide, fingers being about as long as palm. There is a sternal protuberance each side at base of leg 3 in addition to sternal spines at base of leg 4. Dactylii of legs 2-4 are 3/4 times longer than their propodii with 4-7 prickly spines along ventral edge. Dactylus of leg 5 is slightly less than 1/4 as wide as long with 1-2 feathered setae, 5-7 hooked feelers and 2 saw-like feelers. Uropod is about 2/3 as long as telson with 11-13 setae on exopod. One seta may be present on protopod, though 2 setae were figured by OSHIMA (1938).

There is 1 mastigobranch bearing long filamentous setae on maxillipeds 1 and 3, 2 arthrobranchs each on maxillipeds 2, 3 and leg 1, and 1 arthrobranch on legs 2 and 3. Thus, the gill formula is completed as in the adult except 1 mastigobranch on maxilliped 2.

Remarks AIKAWA (1929) was the first to describe zoea of this crab. He obtained the first zoea from eggs but overlooked lateral spines on carapace. This was revised by himself in a later paper (AIKAWA, 1937) in which, however, he state that antennal spinous process bears only a single row of spinules, hind end of all abdominal somites are rounded and telson has two outer spines only. These are not entirely correct.

OSHIMA (1938) gives a good description and figures of zoea and megalopa reared from egg in the live boxes anchored in the shallow sea. In his description, however, rudiment of maxilliped 3 in stages 1 and 2 are overlooked, and antennal spinous process is figured as bearing many rows of spinules. These are not the case in the present materials.

Asymmetrical increase of extra inner setae of telson in later stages is also observed by OSHIMA (1938) and YATSUZUKA (1957) and seems to be common in the zoea of this crab. In other known zoeae these setae usually increase in



Fig. 3. *Portunus trituberculatus:* megalopa. A, dorsal; B, carapace, lateral; C, abdomen, lateral; D, thoracic sternite and basal parts of legs, ventral; E, mandibles; F, maxillule; G, maxilla; H-J, maxillipeds 1-3; K-O, legs 1-5; P, last segment of leg 5. Scales indicate 0.1 mm.

pairs.

YATSUZUKA (1957) studied variation in the number of zoeal stages and found that the last zoea of stage 5 was much more developed and larger than the last zoea of stage 4, but was less well developed than the latter in stage 4. He concluded, therefore, that the extra stage may occur among zoeae in which growth and development were retarded.

Portunus gladiator FABRICIUS

The "IBO-GAZAMI" ranges from Inuboe-zaki to Kyushu along Pacific coast of Japan. They live on sandy flats of 30-80 m. deep attaining 68 mm. across carapace. They are fairly common among the gill net catches at Arasaki district. Berried females were found in May-June. Early eggs are oval and 0.27×0.31 mm. in size and yellowish in color.

Larvae were not described before. Eggs were hatched on June 8, 1968, but they did not live beyond stage 1.

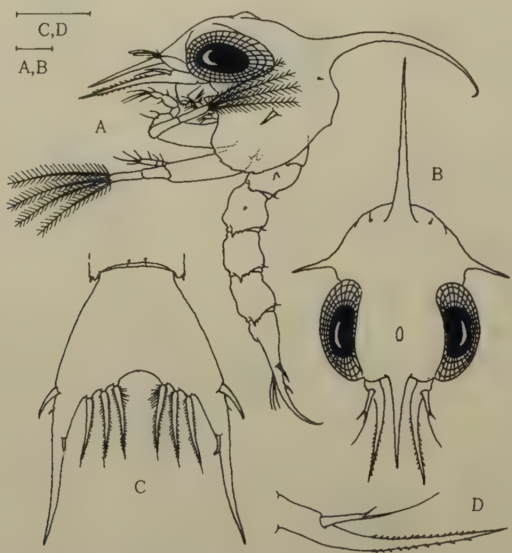


Fig. 4. *Portunus gladiator:* zoea stage 1. A, lateral; B, carapace, dorsal; C, telson, dorsal; D, antenna. Scales indicate 0.1 mm.

ZOEA (Fig. 4; A-D)

Zoea is very like *P. trituberculatus,* but differs from it in somewhat smaller size and the following minor details. Postero-lateral spines on abdominal somites 3-5 are much smaller than in the latter species, and accompanied dorsally by minute denticles in stage 1 at least. Telson is distinctly less than twice as long as wide. Insertion of outer spine 1 is level with or slightly behind that of inner seta 1. Antenna is longer than rostral spine in stage 1. Apical inner spine of

exopod is twice as long as the exopod less terminal spine.

Stage 1. From spine to spine: 1.08-1.14 mm. in 5 specimens.

Eyes are sessile. Abdomen is of 5 somites plus telson. Telson is 3/4 times longer than wide, and fork is 1/4 times longer than the rest of telson. Outer spine 1 is longer than spine 3. Inner seta 1 exceeds tip of outer spine 3 by its distal 1/8. Maxillipeds bear 4 swimming setae.

Genus *Charybdis* De Haan

Among the genus *Charybdis* 6 species are more or less common in the warm water areas of Japan. They are *Ch. bimaculata, Ch. truncata, Ch. miles, Ch. japonica, Ch. acuta* and *Ch. cruciata.* All but the last are more or less known of their larval stages. The larvae of the first three species are described here. Larvae of *Ch. acuta* have already been reported by Kurata & Omi (1969) and those of *Ch. japonica* by Aikawa (1937), Yatsuzuka (1952, 1957) and Kurata & Nishina (1975). Aikawa described the last zoea and megalopae of *Ch. bimaculata* taken from plankton, but his identification was open to question because he recognized two stages in the megalopa. *Ch. japonica* are sold in the local market, but the other members of the genus do not have any commercial values owing to their small size.

ZOEA

All the known zoea of *Charybdis* have the following characters in common. Carapace has all the spines. Rostral spine is long and straight. Dorsal spine bends posteriorly and is much longer than rostral spine. Lateral spines are short. Ventral margin of carapace is more or less denticulated. Eyes are very large. There is an inconspicuous dorsal knob above stomach. Coloration is like *Portunus.*

There are lateral hooks on abdominal somites 2 and 3, and postero-lateral spines on somites 3-5 in all stages. The postero-lateral spines are distinct from stage 1 and become very long in later stages.

Telson is typically forked with 3 or 2 outer spines. Spines 1 and 3 are distinct and spinous in all stages, while spine 2 is minute and hair-like in stage 1, disappearing in later stages or lacking from stage 1 in some species. Spine 1 is almost as large as or smaller than spine 3 except in stage 1 in some species. Insertion of spine 1 is distinctly behind that of inner seta 1, and that of spine 3 is more or less behind the tip of spine 1. There are 3+3 inner setae in stage 1 and 1 or 2 pairs of extra ones in later stages.

Structure of antennule, antenna and mouth parts is very like *Portunus.*

Development of the remaining limbs also follows quite a similar sequence with that of *Portunus.*

MEGALOPA

Megalopa is known with certainty only in *Ch. acuta* (Kurata & Omi, 1969). As in zoea, megalopa of *Charybdis* is very like *Portunus.* The characters common

to both are the presence of one-spined rostrum, ischial spine on leg 1, coxal spine on leg 2, large sternal spine at the base of leg 4, and postero-lateral spine on abdominal somite 5. Absence of dorsal spines and conspicuous protuberances on carapace, presence of 8 jointed antennal flagellum and paddle shaped leg 5 bearing feelers are also common to both.

It is quite difficult at present to tell *Charybdis* megalopa as a whole apart from *Partunus* owing to the scarcity of knowledge. However, informations from the study of plankton specimens in addition to those from reared materials show that distinguishing characters of megalopa of *Charybdis* from *Portunus* seem to be in the absence of spine on carpus of leg 1, and smaller size of sternal spine at base of leg 4 extending hardly beyond hind end of abdominal somite 2.

Charybdis bimaculata (Miers)

The "FUTAHOSHI ISHIGANI" is quite common from Sagami Bay to Kyushu in Japan on sandy bottoms of 20-400 meter deep. It also ranges very widely in tropical waters of Indo-West Pacific and East Africa. It is very common in the gill net catches at Arasaki district attaining 34 mm. across carapace. Berried females were found in June. Early eggs are orange-yellow in color and 0.33 mm. in diameter. Eggs hatched out on July 18, 1964 and were reared up to stage 4 which, judging from development of limb buds and pleopods, seems to be penultimate zoea. No megalopa were obtained.

ZOEA (Fig. 5; A-K)

Rostral spine is about 2/3 as long as carapace. Dorsal spine curves without terminal hook and is longer than rostral spine but shorter than carapace. Postero-lateral spines on abdominal somite 3 are somewhat longer than those of somite 4, reaching behind hind end of somite 4 in later stages. Outer spine 2 of telson is hair-like in early stages and disappears from stage 3. Spine 1 is longer than spine 3 in stage 1, and is almost as long as the latter in later stages. Inner seta 1 is 1/2 as long as fork and reaches slightly beyond tip of outer spine 3.

Antenna is nearly as long as or slightly shorter than rostral spine. Exopod less spines is 1/5-1/4 as long as spinous process. Apical inner spine of exopod is slightly longer than exopod including terminal spine in early stages, while in later stages it is almost as long as the latter.

Stage 1. From spine to spine: 1.08-1.14 mm. in 15 specimens.

Postero-lateral spine on abdominal somite 3 is about 1/2 as long as somite 4. Telson is 2/3 times longer than wide. Fork is only slightly longer than the rest of telson. Outer spine 2 is hair-like. Outer spine 1 is longer than spine 3. Antenna has no endopod. There are no leg buds or pleopods. Maxillipeds bear 4 swimming setae.

Stage 2. From spine to spine: 1.20-1.30 mm in 7 specimens.

Postero-lateral spine on abdominal somite 3 is almost as long as somite 4. Telson is almost twice as long as wide. Fork is 1/4 times longer than the rest

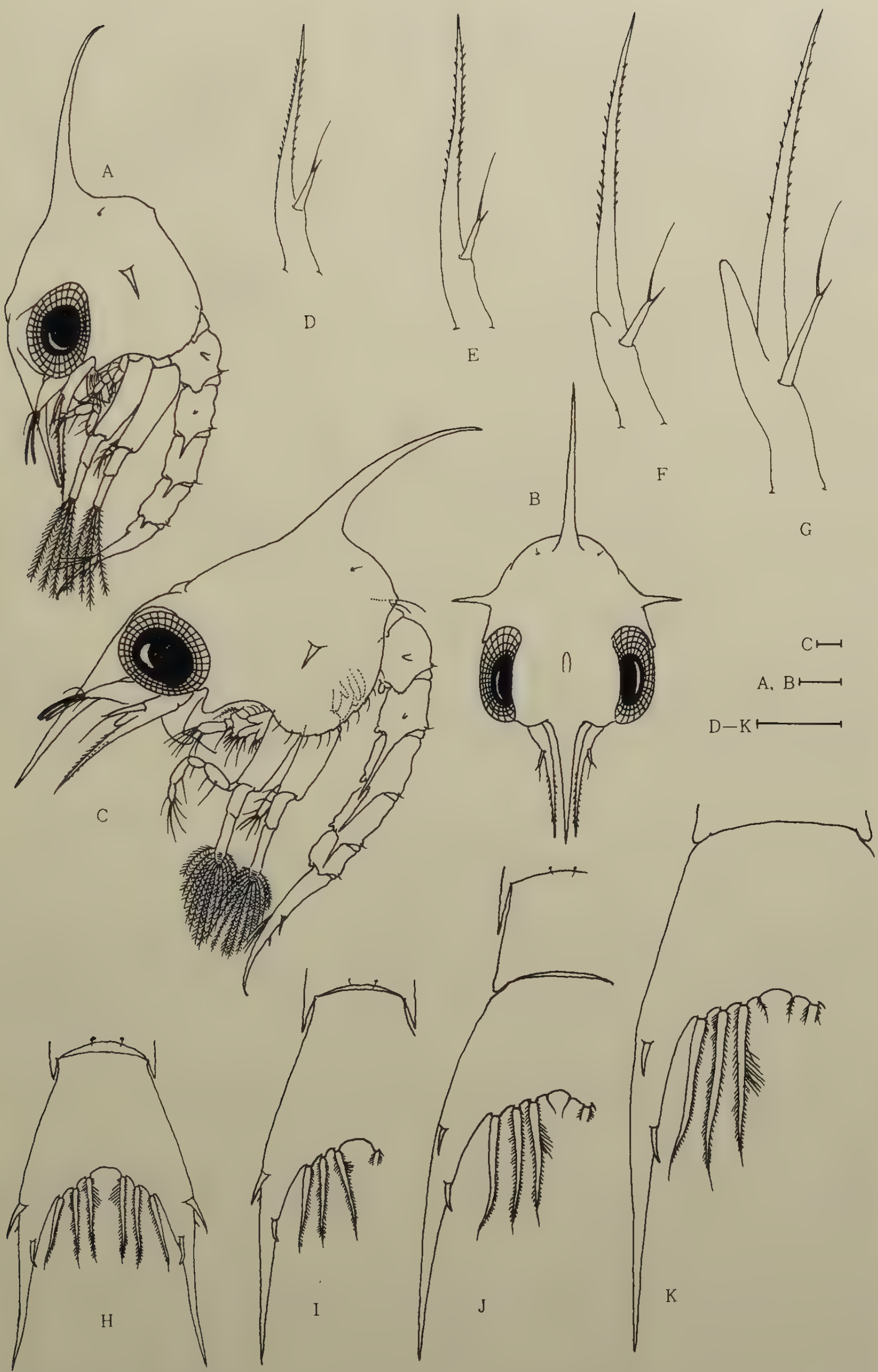


Fig. 5. *Charybdis bimaculata:* zoeal stages 1-4. A, stage 1, lateral; B, the same, carapace, dorsal; C, stage 4, lateral; D-G, antenna; H-K, telson, dorsal. Scales indicate 0.1 mm.

of telson. Outer spine 1 is as long as spine 3. There is a pair of extra inner setae inside. Maxillipeds bear 6 swimming setae.

Stage 3. From spine to spine: 1.35-1.56 mm. in 4 specimens.

Abdominal somite 6 is segmented off from telson. Telson is now about 1/2 times longer than wide. Fork is somewhat more than twice as long as the rest of telson. Postero-lateral spine on abdominal somite 3 reaches slightly beyond hind end of somite 4. Leg buds are unfolded but no pleopods. Maxillipeds bear 8 swimming setae.

Stage 4. From spine to spine: 2.1-2.2 mm. in 3 specimens.

Antennal endopod is almost as long as exopod less spines. Leg buds are large but unsegmented. Pleopod buds are present, though small. Telson still bears a pair of extra inner setae.

Remarks AIKAWA (1937) described fourth zoea and megalopa obtained from plankton from the East China Sea. His fourth zoea, however, is apparently different from present specimens described above, having antennal exopod more than 1/2 as long as spinous process, and endopod only about 1/2 as long as exopod less spines. He recognized two different size groups among his specimens of megalopa and assumed to represent different stages of the same species. Unfortunately, he did not describe the differences between the two stages in detail, except size, number of setae on uropod and of segment of antennal flagellum. These minor differences, however, seem to be enough to conclude that these two groups represent different species rather than different stages of the same species.

Charybdis truncata (FABRICIUS)

The "HIROHA ISHIGANI" ranges in Japan from Tokyo Bay to Kyushu on sand-mud bottoms of 20-50 meter deep, attaining 47 mm. across carapace. They are very common in gill net catches at Arasaki district in June, when majority of females are in berry. Any of the larval stages are not known before. Early eggs are orange-yellow in color. Eggs were hatched several times during spawning season in 1967-68 and were reared up to stage 3.

ZOEA (Fig. 6; A-H)

Zoea looks more slender than *Ch. bimaculata* owing to its slender and long dorsal spine, which is longer than carapace as well as rostral spine. Postero-lateral spines on abdominal somite 3 are slightly shorter than those on somite 4 in early stages at least. Outer spine 2 of telson is hair-like, disappearing in later stages. Outer spine 1 is almost as long as or shorter than spine 3 in all stages examined. Antennal exopod is of moderate length. Apical inner spine is almost as long as exopod including terminal spine. Inner seta 1 of telson is about 1/2 as long as fork, reaching only slightly behind tip of outer spine 3.

Stage 1. From spine to spine: 1.11-1.20 mm. in 15 specimens.

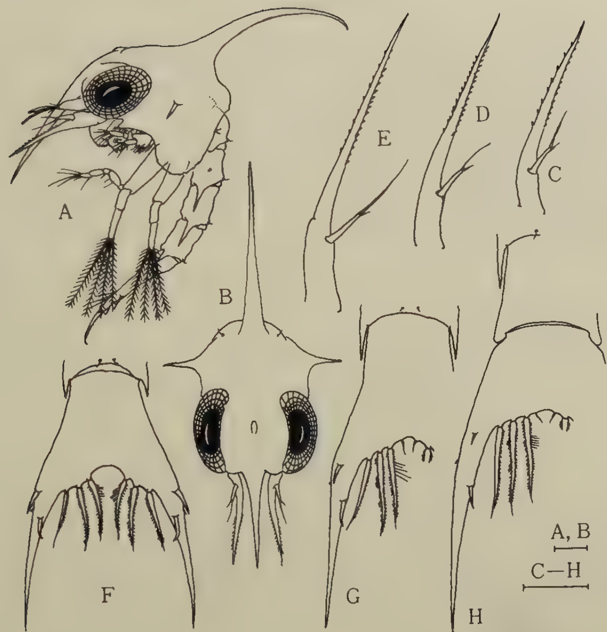


Fig. 6. *Charybdis truncata:* zoeal stages 1-3. A, stage 1, lateral; B, the same, carapace, dorsal; C-E, antenna, stages 1-3; F-H, telson, dorsal, stages 1-3. Scales indicate 0.1 mm.

Dorsal spine is slightly longer than carapace. Postero-lateral spine of abdominal somite 3 is about 1/2 as long as somite 4. That of somite 4 is about 1/5 longer than that of somite 3. Telson is 3/4 times longer than wide. Fork is 1/3 times longer than the rest of telson. Outer spine 1 is almost as long as or slightly shorter than spine 3. There are 3+3 inner setae. Antenna has no endopod and is as long as rostral spine. There are no legs or pleopods. Maxillipeds bear 4 swimming setae.

Stage 2. From spine to spine: 1.26–1.38 mm. in 8 specimens.

Telson is twice as long as wide. Fork is 1/4 times longer than the rest of telson. Outer spine 1 is distinctly smaller than spine 3. There is a pair of extra inner setae. Postero-lateral spine on abdominal somite 3 is only slightly shorter than somite 4. Antenna is somewhat shorter than rostral spine. Maxillipeds bear 6 swimming setae.

Stage 3. From spine to spine: 1.56–1.86 mm. in 3 specimens.

Telson is now somewhat less than twice as long as wide. Fork is 1/2 times more than twice as long as the rest of telson. Small leg buds are unfolded. Antennal endopod is beginning, but no pleopods are present. Maxillipeds bear 7–8 swimming setae.

Charybdis miles (DE HAAN)

The "AKA ISHIGANI" ranges from Tokyo Bay to Kyushu in Japan, further extending to Hongkong and Indian waters. They live on sandy bottoms of 10–100 meter deep, attaining 83 mm. across carapace. At Arasaki district berried females are found in gill net catches in June–July. Larval stages are not known before. Early eggs are orange-yellow and 0.31 mm. in diameter. Eggs hatched out on June 28, 1964 but none of the larvae survived beyond the first zoea.

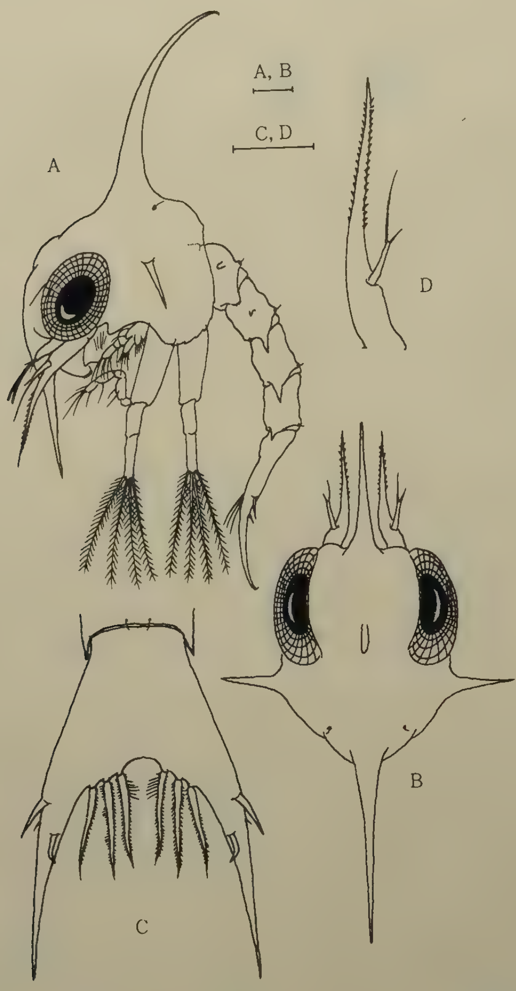


Fig. 7. *Charybdis miles:* zoeal stage 1. A, lateral; B, carapace, dorsal; C, telson, dorsal; D, antenna. Scales indicate 0.1 mm.

ZOEA (Fig. 7; A-D)

Dorsal spine is almost as long as carapace. Outer spine 2 of telson is hairlike in stage 1. Outer spine 1 is distinctly longer than spine 3 in stage 1 at least. Postero-lateral spine on somite 3 is almost as long as that on somite 4. Apical spine of antennal exopod is distinctly longer than exopod including terminal spine. Inner seta 1 of telson is somewhat less than 1/2 as long as fork, exceeding tip of outer spine 3 by its distal about 1/4. Antenna is slightly shorter than rostral spine in stage 1.

Stage 1. From spine to spine: 1.14-1.26 mm. in 10 specimens.

Telson is 3/4 times longer than wide. Fork is 1/4 times longer than the rest of telson. Postero-lateral spine on abdominal somite 3 is somewhat less than 1/2 as long as somite 4. Maxillipeds bear 4 swimming setae.

Genus *Thalamita* Latreille

Fourteen species of *Thalamita* are known from Japanese waters (Sakai, 1939), of which *Th. picta, Th. sima* and *Th. prymna* are very common among sea weeds on rocky shores. Zoeae of the last two species are described here for the first time. Larvae of *Th. picta* are not known.

ZOEA

Zoea is very like *Portunus* and *Charybdis* in every essentials including coloration. Carapace has all the spines and an inconspicuous anterior dorsal knob. However, dorsal spine is much shorter than in the other two genera compared with carapace length. Telson has 2 or 3 outer spines, but, unlike the other two genera, spine 1 is only faintly seen or may be lacking. Spine 2 is hair-like as in the other two genera dwindling in later stages. While spine 3 is spinous in all stages. Inner seta 1 extends far beyond tip of outer spine 3. Antenna is distinctly longer than rostral spine in early stages at least, with exopod of moderate length. The armatures of abdomen, mouth parts, maxillipeds and remaining limbs are quite similar as in other two genera.

MEGALOPA

Megalopa as typified by *Th. sima* shares every essential characters in common with the other two genera, bearing one spined rostrum, coxal spine on leg 2, postero-lateral spines on abdominal somite 5, paddle shaped leg 5, sternal spines at base of leg 4, and 8 jointed antennal flagellum.

Carapace has no conspicuous protuberances. There are no ischial or carpal spines on leg 1. Sternal spine at base of leg 4 is much smaller than in the other two genera. It is hardly seen from above.

Thalamita sima H. M. Edward

The "FUTABA BENITSUKE" ranges from Tokyo Bay to Kyushu in Japan,

further extending widely in Indo-West Pacific, East Africa and Red Sea. They live between tide marks of rocky shores and are fairly common at Arasaki district attaining 46 mm. across carapace. Larvae are not known before. Berried females were obtained several times from gill net catches during May-June. Eggs hatched out on June 17, 1965 have been reared up to megalopa feeding on newly hatched *Artemia* nauplii.

ZOEA (Fig. 8; A-M)

Dorsal spine is not much longer than rostral spine and shorter than carapace. Postero-lateral spines on abdominal somite 3 are almost as long as or slightly longer than those of somite 4, reaching beyond hind end of somite 4 in the last stage. Antenna is longer than rostral spine in early stages, with exopod of moderate length. Apical inner spine of exopod is as long as or slightly longer than the rest of exopod including terminal spine.

Stage 1. From spine to spine: 0.96-1.07 mm. in 15 specimems.

Eyes are sessile. Abdomen is of 5 somites plus telson. Postero-lateral spine on abdominal somite 3 is almost as long as that of somite 4, and is about 2/5 as long as somite 4. Telson is 3/4 times longer than wide. Outer spine 1 is visible only under high magnification. Spine 2 is hair-like. Spine 3 is spinous, bending inward distally, being inserted at proximal 1/4 of fork. Inner setae is 3+3. Seta 1 is 1/2 as long as fork, reaching beyond tip of outer spine 3 by its distal 1/5-1/4. Antenna has no endopod, and is 1/5 times longer than rostral spine. Exopod less spines is about 1/4 as long as spinous process. Apical inner spine is almost as long as or slightly longer than the rest of exopod including terminal spine. Maxillipeds bear 4 swimming setae.

Stage 2. From spine to spine: 1.08-1.26 mm. in 7 specimens.

Eyes are stalked. Rostral spine is nearly as long as dorsal spine. Postero-lateral spines of abdominal somite 3 are slightly longer than those of somite 4, and are somewhat more than 1/2 as long as somite 4. Telson is almost twice as long as wide. Fork is slightly longer than the rest of telson. Outer spine 1 is hardly visible. Spine 2 is hair-like but distinct. There is a pair of extra inner setae. Antenna is still longer than rostral spine. Minute leg buds are present behind rudiment of maxilliped 3. Maxillipeds bear 6 swimming setae.

Stage 3. From spine to spine: 1.64 mm. in 2 specimens.

Abdomen is of 6 somites plus telson. Telson is somewhat less than twice as long as wide. Fork is a little less than twice as long as the rest of telson. Inner seta 1 is almost 2/3 as long as fork, exceeding tip of outer spine 3 by its distal 1/3. Postero-lateral spines of abdominal somite 3 are about 3/4 as long as somite 4. Antennal endopod is beginning. Leg buds are unjointed. There are no pleopods. Maxillipeds bear 8 swimming setae.

Stage 4. From spine to spine: 2.04-2.34 mm. in 4 specimens.

Antenna is almost as long as rostral spine. Endopod is slightly shorter than exopod less spines. Telson is 3/4 times longer than wide. Outer spine 2 is very

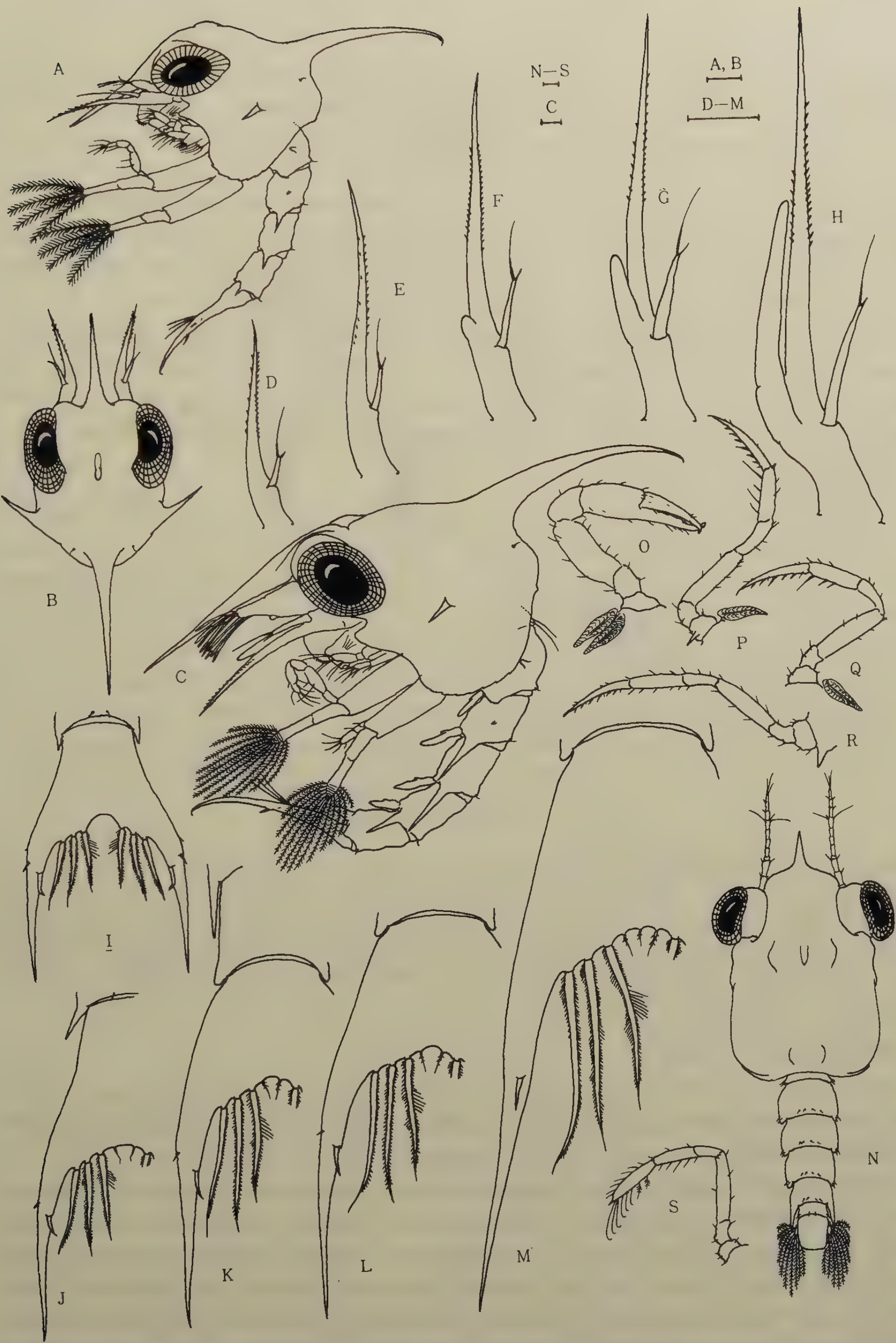


Fig. 8. *Thalamita sima:* zoeal stages 1-5 and megalopa. A, stage 1, lateral; B, the same, carapace, dorsal; C, stage 5, lateral; D-H, antenna, stages 1-5; I-M, telson, dorsal, stages 1-5; N, megalopa, dorsal; O-S, the same, legs 1-5. Scales indicate 0.1 mm.

minute but still visible. Postero-lateral spines of abdominal somite 3 are about 7/8 as long as somite 4. Leg buds are large but unjointed. There are pleopod buds. Maxillipeds bear 9-10 swimming setae.

Stage 5. From spine to spine: 2.6-2.9 mm. in 2 specimens.

Antenna is somewhat shorter than rostral spine, with endopod which is longer than exopod. Exopod less spines is slightly less than 1/3 as long as spinous process. Apical inner spine is 3/4-3/5 as long as the rest of exopod less terminal spine. Postero-lateral spine on abdominal somite 3 reaches beyond hind end of somite 4. Telson is a little more than twice as long as wide with 3 extra inner setae. Fork is 3/4 times longer than the rest of telson. Outer spine 2 disappears. Maxilliped 3 and legs are large and jointed,though not yet functional. Pleopods are as long as respective somite. Maxillipeds bear 11-12 swimming setae.

MEGALOPA (Fig. 8; N-S)

Carapace length: 1.71 mm., Total length: 2.85 mm. Central spine of rostrum is about 1/2 as long as the rest rostrum. Carapace has no conspicuous protuberances or dorsal spines. Postero-lateral spine on abdominal somite 5 reaches to about middle of telson. Uropod bears 1 seta on protopod and 10 setae on exopod. Antennal flagellum exceeds tip of rostrum by its distal 4 segments. Leg 1 has no spines. Leg 2 has a spine on coxa. Sternal spine at base of leg 4 is much smaller than in *Portunus* and *Charybdis*. Dactylii of legs 2-4 bear 6 spinules along their ventral edges. Last segment of leg 5 is paddle shaped with feelers.

Thalamita prymna (HERBST)

The "BENITSUKE GANI" lives on rocky shores of 20-30 meters deep, and also between tide marks. They range widely in Indo-West Pacific, East Africa and Red Sea attaining 75 mm. across carapace. A berried female was separated from gill net catches at Arasaki district, and the egg hatched out on August 10, 1967. But none of the larvae survived beyond the first zoea.

ZOEA (Fig. 9; A-D)

Zoea is so much like *Th. sima* in every details that it is almost impossible to tell them apart except size. The first stage zoea of this species is somewhat larger than corresponding stage of *Th. sima*.

Dorsal spine is much shorter than carapace. Postero-lateral spines on abdominal somites 3-5 are of moderate length from stage 1, those of somite 3 are as long as those of somite 4. Outer spine 1 of telson may be seen under high magnification at least in stage 1, spine 2 is hair-like, while spine 3 is spinous bending inward distally. Inner seta 1 exceeds well beyond tip of outer spine 3. Antenna is longer than rostral spine in stage 1 at least. Apical inner spine is distinctly longer than the rest of exopod including terminal spine.

Stage 1. From spine to spine: 1.08-1.20 mm. in 5 specimens.

Rostral spine is about 3/5 as long as carapace and dorsal spine is 3/4 as long

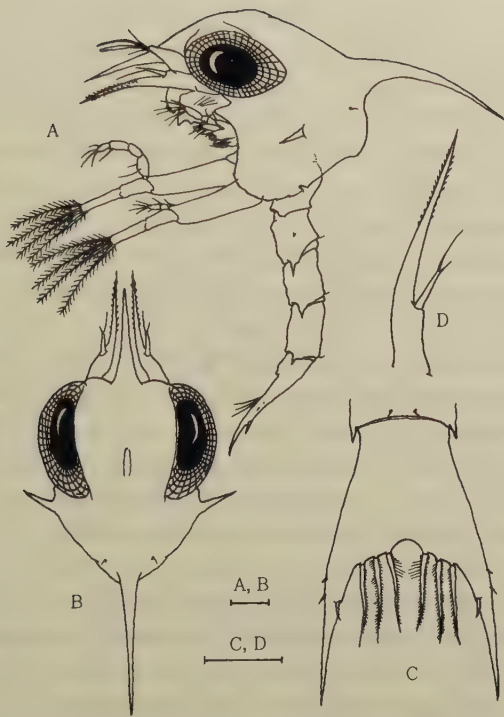


Fig. 9. *Thalamita prymna:* zoeal stage 1. A, lateral; B, carapace, dorsal; C, telson, dorsal; D, antenna. Scales indicate 0.1 mm.

as the latter. Postero-lateral spine on abdominal somite 3 is 2/5 as long as somite 4. Telson is slightly less than twice as long as wide. Fork is about 1/5 times longer than the rest of telson. Inner seta 1 reaches beyond tip of outer spine 3 by its distal about 1/3. Antenna has no endopod. There are no legs or pleopods.

DISCUSSION

Raja Bai Naidu (1955) described and figured first zoea of *Scylla serrata* hatched from egg in the the laboratory, which is very like *Portunus* in every essentials including the armature of telson, bearing spinous outer spines 1 and 3, lacking spine 2. It differs, however, from the other known zoea of Portuninae in the armatures of abdominal somites. Postero-lateral spines on abdominal somites 3 and 4 are very small without accessory denticles and sides of somite 5 are rounded behind in stage 1 at least. In *Portunus gladiator* these armatures are also very small but accompanied by accessory denticles and sides of somite 5 are pointed behind as in the preceeding somites. In addition, zoea of *Scylla* has maxillular endopod bearing 4 setae, instead of 6 setae as in other Portuninae.

The zoeae of Portuninae including *Scylla* may be distinguished from all the

known zoeae of Brachyura by the following criteria.

1. Carapace has all the spines 2
   Carapace lacks certain of the spines .... non Portuninae
   (including Portunidae: Carcininae, *Carcinus* and Portumuninae, *Portumnus*)
2. Telson is typically forked 3
   Telson is not typically froked .... non Portuninae
3. Antenna is of moderate length with spinous process bearing two rows of spinules and endopod ending in a short spine and one long apical inner spine 4
   Antenna is rudimentary, or of moderate length with spinous process bearing more than two rows of spinules, and exopod being spinous as a whole with two or more lateral spines or ending in a short terminal spine and two apical inner spines .... non Portuninae
   (including Portunidae, Macropipinae: *Macropipus*)
4. One pair of lateral hooks only on abdominal somite 2
   .... Cancridae: *Cancer* (LEBOUR, 1928; AIKAWA, 1937)
   Corystidae: *Corystes* (LEBOUR, 1928, INGLE & RICE, 1971)
   More than one pair of lateral hooks on abdominal somites 5
5. Four pairs of lateral hooks on abdominal somites 2-5
   .... Grapsidae, Plagusiinae: *Plagusia* (KURATA, unpublished)
   Portunidae, Macropipinae: *Ovalipes*
   Two pairs of lateral hooks on abdominal somites 2 and 3 6
6. Rostral spine of carapace distinctly bends upward. Postero-lateral spines of abdominal somites 3-5 are robust, ending in a blunt tip and not much different in length one another
   .... Parthenopidae, Parthenopinae:
   Lambrus (KURATA, unpublished) and *Parthenope* (YANG, 1971)
   Rostral spine of carapace is almost straight. Postero-lateral spines of abdominal somites 3-5 are slender, ending in a pointed tip. Spines of somite 5 are much shorter than those of somites 3 and 4 7
7. Telson outer spines 1 and 3 are inserted close each other near the base of fork, spine 1 well exceeding insertion of spine 3. Apical inner spine of antennal exopod is very long, being more than 1/2 as long as spinous process .... Calappidae, Calappinae:
   Calappa (AIKAWA, 1937; RAJA BAI, 1959; KURATA, unpublished) and *Hepatus* (COSTLOW & BOOKHOUT, 1962; KURATA, 1970)
   Telson outer spines 1 and 3 are set apart each other, spine 1 hardly exceeding insertion of spine 3. Apical inner spine of antennal exopod is relatively short, being less than 1/2 as long as spinous process
   .... Portunidae, Portuninae:
   Scylla, Portunus, Charybdis, Thalamita, and *Callinectes*

Among the family Portunidae certain other genera are more or less known of their larval stages. They may be distinguished from the three genera described here by the following characters.

Zoeae of *Carcinus* (WILLIAMSON, 1903) and *Portumnus* (LEBOUR, 1944) differ from all the other known Portunidae in lacking lateral spines on carapace. Among Macropipinae, *Ovalipes* (COSTLOW & BOOKHOUT, 1969) differs from the other known members of the subfamily in bearing 4 pairs of lateral hooks on abdominal somites 2–5. *Macropipus* (LEBOUR, 1928 as *Portunus;* GOLDSTEIN, 1971) has antennal exopod ending in two or three spines of varied length. Telson has three pairs of outer spines which are all spinous and not very much different in length one another, excepting *M. puber* in which spine 2 disappears in later stages. Postero-lateral spines on abdominal somites 3–5 are accompanied with accessory denticles in all stages. Lateral hooks on abdominal somite 3 disappear in later stages. According to LEBOUR (1928, 1944) *Polybius* resembles *Macropipus* very closely and no characters could be found to tell them apart. In *Bathynectes* (ROBERT, 1969), outer spine 1 of telson is very much longer than the other two and all the spines are distinctly spinous in all stages.

Zoea of *Callinectes* (COSTLOW & BOOKHOUT, 1959; KURATA, 1970) is very like *Portunus* in every details. The other American species of *Portunus* so far known have a general characters of the genus (KURATA, 1970). Thus, the zoeae of the known Portuninae as a whole seem to differ from the other members of Portunidae in the condition of the outer spine 2 of telson. It is minute or absent in all the known Portuninae, while is large and spinous in all stages in other members of Portunidae except *Macropipus puber.*

The outer spine 1 of telson is minute or absent in *Thalamita,* is spinous but tends to be smaller than spine 3 in *Charybdis* and is always larger than spine 3 in *Scylla, Callinectes* and *Portunus.*

Key to the known zoeae of Japanese genera of Portuninae

1. Outer spine 1 of telson is distinct and spinous. Dorsal spine is not much shorter or even longer than carapace 2
   Outer spine 1 of telson is hair-like or absent. Dorsal spine is much shorter than carapace .... *Thalamita*
2. Outer spine 1 of telson is level at insertion with that of inner seta 1, except in later stages of *P. pelagicus.* Spine 1 is much longer than spine 3 .... *Portunus*
   Outer spine 1 of telson is distinctly behind at insertion to that of inner seta 1. Outer spine 1 is about as long as or much shorter than spine 3, except in stage 1 .... *Charybdis*

Key to the known zoeae of Japanese species of Portunus

1. Antennal exopod less spines is of moderate length being at least 1/5 as

long as spinous process. 2

Antennal exopod less spines is very short, being less than 1/10 as long as spinous process .... *P. sanguinolentus*

2. Antenna is longer than rostral spine. Apical inner spine of antennal exopod is about twice as long as the rest of exopod less terminal spine. Postero-lateral spines on abdominal somites 3-5 bear accessory denticles .... *P. gladiator* (stage 1 only)

   Antenna is more or less shorter than rostral spine. Apical inner spine of antennal exopod is much less than twice as long as the rest of exopod less terminal spine. Postero-lateral spine on abdominal somites 3-5 is simple without accessory denticles 3

3. Outer spine 1 of telson almost reaches insertion of spine 3. Apical inner spine of antennal exopod is longer than the rest of exopod including terminal spine .... *P. hastatoides* (stage 1 only)

   Outer spine 1 of telson ends before the insertion of spine 3. Apical inner spine of antennal exopod is nearly as long as or shorter than the rest of exopod including terminal spine. 4

4. Inner seta 1 of telson reaches well behind tip of outer spine 3. Insertion of outer spine 1 is level with that of inner seta 1. Rostral spine is shorter than carapace. Antenna is slightly shorter than rostral spine .... *P. trituberculatus*

   Inner seta 1 of telson only sligtly exceeds tip of outer spine 3. In later stages insertion of outer spine 1 is behind that of inner seta 1 and rostral spine is longer than carapace. Antenna is much shorter than rostral spine .... *P. pelagicus*

Key to the known zoeae of Japanese species of Charybdis

A. Stage 1.

1. Antenna is almost as long as rostral spine. Inner seta 1 of telson reaches behind tip of outer spine 3 2

   Antenna is about 2/3 as long as rostral spine. Inner seta 1 of telson does not exceed tip of outer spine 3. Dorsal spine is much longer than carapace .... *Ch. japonica*

2. Dorsal spine is almost as long as or shorter than carapace. Outer spine 1 of telson is longer than spine 3 3

   Dorsal spine is somewhat longer than carapace. Outer spine 1 of telson is shorter than spine 3 .... *Ch. truncata*

3. Dorsal spine is almost as long as carapace 4

   Dorsal spine is distinctly shorter than carapace ....*Ch. bimaculata*

4. Inner seta 1 of telson exceeds tip of outer spine 3 by its distal 1/4. Apical inner spine of antennal exopod is longer than the rest of exopod including terminal spine. Postero-lateral spines on abdominal somite

3 are nearly as long as those of somite 4 .... *Ch. miles*
Inner seta 1 of telson only slightly exceeds tip of outer spine 3.
Apical inner spine of antennal exopod is almost as long as the rest of exopod including terminal spine. Postero-lateral spines on abdominal somite 3 are shorter than those of somite 4 .... *Ch. acuta*

B. Stage 2 and later.

(*Ch. miles* is not known)

1. Rostral spine is longer than carapace. Outer spine 1 of telson is much shorter than spine 3. Inner seta 1 only slightly exceeds tip of outer spine 3. Postero-lateral spines of abdominal somite 3 are somewhat shorter than those of somite 4. Antenna is very much shorter than rostral spine .... *Ch. japonica*
   Rostral spine is not longer, usually much shorter, than carapace. Postero-lateral spines of abdominal somite 3 are almost as long as or longer than those of somite 4 2
2. Outer spine 1 of telson is much shorter than spine 3. Inner seta 1 of telson only slightly exceeds tip of outer spine 3 .... *Ch. truncata*
   Outer spine 1 of telson is almost as long as spine 3. Inner seta 1 well exceeds tip of outer spine 3 3
3. Telson fork is less than 1/3 longer than the rest of telson in stage 2, and is not longer than twice the latter in later stages. Dorsal spine is almost as long as or longer than carapace. .... *Ch. bimaculata*
   Telson fork is more than 1/3 longer than the rest of telson in stage 2, and much longer than twice the latter in later stages. Dorsal spine is mach shorter than carapace. .... *Ch. acuta*

Megalopa of Portuninae may be distinguished easily from the other groups of crabs by the following characters.

1. Paddle shaped leg 5 bearing feelers.
2. One spined rostrum sticking out almost horizontally.
3. Absence of dorsal spines and conspicuous protuberances on carapace.
4. Presence of postero-lateral spines on abdominal somite 5.
5. Antennal flagellum of 8 segments with a pair of long setae at distal end of segment 5.
6. Presence of coxal spine on leg 2.
7. Presence of a pair of large sternal spines (cornua) sticking out behind at the bases of leg 4.

The last mentioned character is quite unique and outstanding since in no other known megalopae these armatures have been observed. The cornua are also present in *Callinectes* (Costlow & Bookhout, 1959; Kurata, 1970) but absent in *Macropipus* and *Portumnus* (Lebour, 1028; Goldstein, 1971).

Megalopae of the three genera described here may be distinguished from one another by the armatures of leg 1. *Portunus* has a hook-like spine on ischium

and carpus, *Charybdis* on ischium only, while in *Thalamita* both spines are absent. The cornua are very long in *Portunus,* of moderate length in *Charybdis* and small in *Thalamita.*

SUMMARY

Larval stages are described in detail of two species of *Portunus,* three species of *Charybdis* and two species of *Thalamita.* All the larvae were hatched from eggs and reared in the laboratory. A tentative key to the known zoeae of Japanese genera and species of Portuninae has been presented and diagnostic characters of megalopa of Portuninae are summarized.

References

AIKAWA, H. (1929) : On larval forms of some Brachyura. *Rec. Oceanogr. Works Jap.* 2, 17–55.

AIKAWA, H. (1937) : Further notes on Brachyuran larvae. *Rec. Oceanogr. Works Jap.* 9, 87–162.

COSTLOW, J. D. and C. G. BOOKHOUT (1959) : The larval development of *Callinectes sapidus* RATHBUN reared in the laboratory. *Biol. Bull.* 116 (3), 373–396.

COSTLOW, J. D. and C. G. BOOKHOUT (1966) : The larval development of *Ovalipes ocellatus* (Herbst) under laboratory conditions. *Jour. Elisha Mitchell Sci. Soc.* 82 (2), 160–171.

GOLDSTEIN, B. (1971) : Developpement larvaire de *Macropipus marmoreus* (Leach) en laboratoire (Crustacea, Decapoda, Portunidae). *Bull. Mus. Nat. Hist. Natur.* Ser. 2, 42 (5), 919–943.

INGLE, R. W. and A. L. RICE (1971) : The larval development of the masked crad, *Corystes cassivelaunus* (Pennant) (Brachyura, Corystidae), reared in the laboratory. *Crustaceana* 20 (3), 271–284.

KURATA, H. (1970) : Larvae of decapod Crustacea of Georgia. *Studies on the life histories of decapod Crustacea of Georgia,* Part III. 122–274, Pls. 1–105. Univ. of Ga. Marine Inst., Sapelo Island, Ga., U. S. A.

KURATA, H. and T. MIDORIKAWA (1975) : The larval stages of the swimming crabs, *Portunus pelagicus* and *P. Sanguinolentus* reared in the laboratory. *Bull. Nansei Reg. Fish. Res. Lab.* 8, 29–38.

KURATA, H. and S. NISHINA (1975) : The zoeal stages of the swimming crabs, *Charybdis japonica* and *Portunus hastatoides* reared in the laboratory. *Bull. Nansei Reg. Fish. Res. Lab.* 8, 21–27.

KURATA, H. and H. OMI (1969) : The larval stages of a swimming crab, *Charybdis acuta. Bull. Tokai Reg. Fish. Res. Lab.* 57, 129–136. (in Japanese with English summary)

LEBOUR, M. V. (1928) : The larval stages of the Plymouth Brachyura. *Proc. Zool. Soc. Lond.* 1928, 473–560, 16 pls.

LEBOUR, M. V. (1944) : The larval stages of *Portumunus* (Crustacea, Brachyura) with notes on some other genera. *Jour. mar. biol. Assoc.* 26 (1), 7–15.

OSHIMA. S. (1938) : Biological and fishery research in Japanese blue crab (*Portunus trituberculatus* Miers). *Jour. Imp. Fish. Exp. St.* 9, 208–212, Pls.2–5. (in Japanese with English summary)

RAJA BAI, K. G. (1959) : Studies on the larval development of Brachyura. III. Development of *Calappa lophos* (Herbst) and *Matuta lunaris* Forskal (Crustacea : Brachyura).

Jour. Zool Soc. India 11 (1), 65–72.

RAJA BAI NAIDU, K. G. (1955): The early development of *Scylla serrata* (Forsk.) de Haan and *Neptunus sanguinolentus* (Herbst). *Ind. Jour. Fish.* 2, 67–76.

ROBERT, M. H., Jr. (1969): Larval development of *Bathynectes superva* (Costa) reared in the laboratory. *Biol. Bull.* 137, 338–351.

SAKAI, T. (1939): Studies on the crabs of Japan. IV. Brachygnatha, Brachyrhyncha. Yokendo, Tokyo, 365–741, Pls. 42–111.

WILLIAMSON, H. C. (1903): On the larval and early young stage, and rate of growth, of the shore crab, (*Carcinus maenas* Leach). 21st *Rep. Fish. Bd. Scot.* 3, 136–179, Pls. 1–7.

YANG, W. T. (1971): The larval and postlarval development of *Parthenope serrata* reared in the laboratory and the systematic position of the Parthenopidae (Crustacea, Brachyura). *Biol. Bull.* 140 (1), 166–189.

YATSUZUKA, K. (1952): The metamorphosis and growth of the larva of *Charybdis japonica* A. Milne Edward. *Bull. Jap. Soc. Sci. Fish.* 17 (11), 353–358. (in Japanese with English summary)

YATSUZUKA, K. (1957): Study of Bracyuran zoea, artificial rearing and development. *Suisangaku Shusei*, 571–590. Univ. of Tokyo Press. (in Japanese)

YATSUZUKA. K. (1962): Studies on the artificial rearing of the larval Brachyuna, especially of the larval blue crab, *Neptunus pelagicus* Linnaeus. *Rep. Usa Mar. Biol. St., Kochi Univ.*, 9 (1), 1–88. (in Japanese with English Summary)

相模湾荒崎産カニ類の幼生 -V. Portuninae 亜科のわたりがに類

倉　田　博

わたりがに類幼生はガザミ，タイワンガザミ，イシガニなどが一応知られている。しかし，主として飼育技術開発に関心のまとがしぼられていたため，自然での生態調査に不可欠なプランクトン標本の同定のための知見は極めて不十分である。

本報告では，日本産 Portuninae 亜科のうち主要な部分を占める *Portunus, Charybdis* および *Thalamita* 3属の幼生について，飼育材料に基ずく形態観察結果の詳細を記載し図解した。さらに，既住の文献を参考にして，知られている限りの Portuninae ゾエアについて，ほかのカニ類との識別法，属の検索表，*Portunus* と *Charybdis* の種の検索表を示し，メガロパの形態的識別点を整理した。

Portuninae 亜科の幼生は，いわゆる基本的な特徴に関しては類似性が非常に顕著である。従って，全体としてほかのカニ類との識別は比較的容易である反面，亜科内種間の識別は相当細かい特徴にまで立入らないと難かしい。

Bull. Nansei Reg. Fish. Res. Lab. (8) 67～79 (1975)

クルマエビの漁業生物学的研究－Ⅰ.

燧灘西部資源の加入量の推定

石岡　清英・高尾　亀次・外間　源治・長谷川　彰*

Studies on the Fishery Biology of Kuruma Prawn, *Penaeus japonicus* BATE-I.

Estimation of the Amount of Recruitment in West Hiuchi-Nada Area of Seto Inland Sea

Kiyohide ISHIOKA, Kameji TAKAO, Genji GEMA and Akira HASEGAWA

SUMMARY

In order to analyze the population dynamics of the prawn, two kinds of data were used. The one was the informations on exact position of fishing operation and number of prawn caught in each operation, which have been obtained from the sample boats. The other was the catch statistics of the whole boats from June to October in 1971.

In the preliminary treatment of the data, calculations were made on the total effective overall fishing intensity (f_T) and the relative index of population size (P_T) in each 5 consecutive day period. The results of calculation from the 5th period (in June) to the 28th period (in October) were used for the later analysis.

Population parameters were estimated according to the two mathematical models, adapted for situations of the actual fisheries and the ecology of the prawn. Dispersion was included in the natural mortality.

The obtained parameters are :

(Model 1)

Migratory stage

Natural mortality coefficient (M) = 0.191/5 days

Catchability coefficient (q) = 0.0129

Recruiting coefficienrt (α) = 0－1.414/5 days

Non-migratory stage

Natural mortality coefficient (M) = 0.0365/5 days

Catchability coefficient (q) = 0.00424

Recruiting coefficient (α) = 0－1.028/5 days

1975年 8 月15日受理，南西海区水産研究所業績第51号

* 東海区水産研究所

(Model 2)

Parameters are identical to those of the non-migratory stage in Model 1.

The population parameters assessed by these two mathematical models were similar to each other, and the following estimations were resulted.

(1) The number of prawn captured within the area and period of study was about 300 thousands.

(2) The recruitments occurred four times from June to October.

(3) The number of total recruitment was 400–500 thousands.

(4) The number of natural mortality (including dispersion) was 80–120 thousands.

1970年からはじまった浅海域における増養殖漁場の開発に関する総合研究の一環として行なわれた「クルマエビの資源培養に関する研究」において，著者らは，愛媛県西条市地先に放流したクルマエビ（*Penaeus japonicus* BATE）の種苗が，燧灘西部の小型底曳網漁業に，どの程度の生産効果をおよぼすかを分担調査した。

西条市地先の干潟調査によれば，稚・幼エビ期を干潟で過ごしたクルマエビは，成長に伴って，沖合いの小型底曳網漁場に移動して行くことが明らかになっている[1),2),4),5)]。本報告では，1971年に行った調査データーにもとづいて小型底曳網漁場における資源解析，特に加入量を検討した結果について報告する。

なお，この報告に当っては，東海区水産研究所土井長之博士に有意義な助言と，校閲をしていただいた。また，倉田博博士および多々良薫博士には終始ご指導を賜った。愛媛県水産試験場東予分場河野慈敬氏には，調査に当り種々の協力をしていただいた。河原津漁業協同組合の方々は，よく調査に協力していただき，貴重な資料を提供していただいた。内海資源部小松登志恵さんに，計算および図の作製をお願いした。これらの方々に深く感謝する。

方 法 お よ び 結 果

解析方法は土井ほか[6)]の方法に従がった。ただし，加入係数については，数学的モデルを多少変更した。

調査データは，Fig. 1 に示す漁場でのクルマエビ漁獲量の約80％を占めている[4)]河原津を根拠地とする小型底曳網漁船約70隻のうち，10隻に依頼した操業日誌と，河原津漁業協同組合のクルマエビ水揚統計とである。操業記録は1海里×1海里（1海里＝1.852㎞）区画ごとのクルマエビ漁獲尾数，曳網海里数を5日ごとにまとめた。また，6月1日から10月25日までを5日ごとの1～30期に区分した。

ここで使用した記号や数式表現は，次のとおりである[6),9)]。

A_i : i 漁区の面積

C_i : 〃 漁獲量（尾数）

X_i : 〃 漁獲努力量（曳網海里数）

とすれば，

漁場面積	$A=\Sigma A_i$
漁 獲 量（尾数）	$C=\Sigma C_i$
努 力 量（曳網海里数）	$X=\Sigma X_i$
各漁区の密度指数	$\phi'_i=C_i/X_i$
資源量指数	$P=\Sigma A_i\cdot\phi'_i$
平均密度指数	$\phi'=\Sigma A_i\cdot\phi'_i/A$
有効努力量	$\tilde{X}=C/\phi'$
努力の有効度	$r=\tilde{X}/X$
有効漁獲強度	$f=\tilde{X}/A$

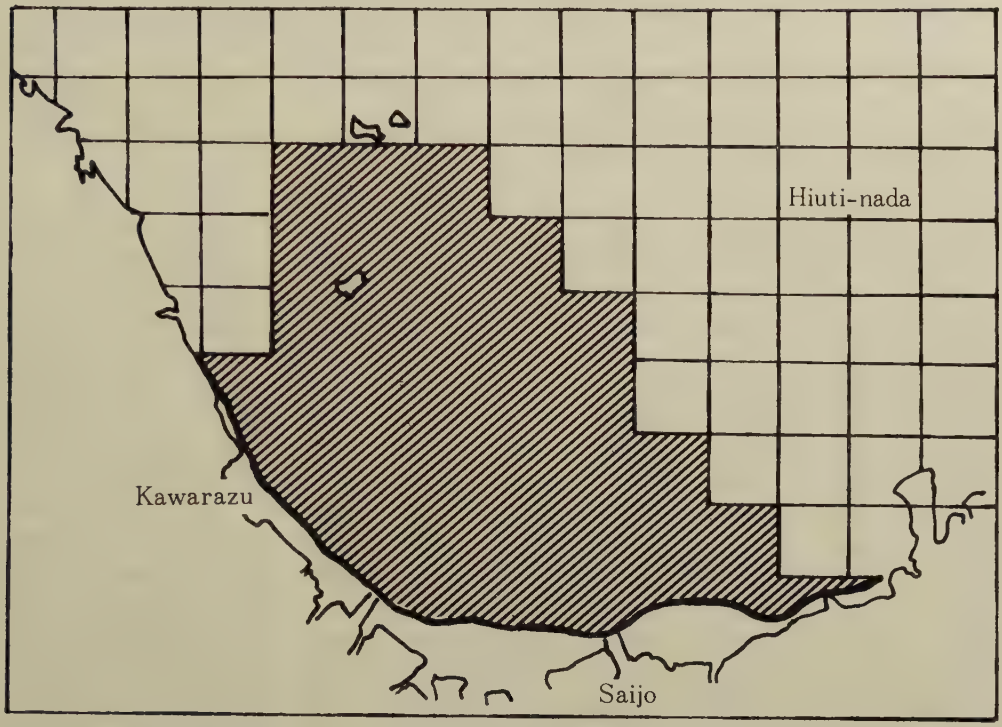


Fig. 1. Map showing the survey area (hatched portion) divided into 1 square mile blocks. Tagging experiments and analysis of catch statistics have revealed that the prawn population within the area is almost exclusively recruited from intertidal flats at Saijo.

となる。

標本船についてそれらの計算結果を5日期ごとに整理し，Table 1 に示す。また，操業区画面積は，時期により3.0平方海里から，44.8平方海里まで変化するが，標識放流個体の再捕位置などから考えて，西条地先干潟から沖合いに移動するクルマエビが移動滞留する範囲，および河原津漁協の所属船が操業する海域は，Fig. 1 に示した斜線の範囲と考えられる[1),2),4),5)]。したがって，ここでは対象とする漁場面積として，全漁場面積A′=34.1平方海里を使用することとした。なお，数ケ月間をこの海域で過ごしたクルマエビは，成長に伴って，一部のものは，北西方向に逸散して行くことが標識放流の結果明らかとなっている[4),5)]。

河原津漁協の水揚統計（重量）を，定期的に調査した漁獲エビの平均体重を使って尾数に換算し，各5日期ごとにまとめて全漁船の漁獲尾数（C_T）とした。C_T と標本船の漁獲尾数（C）との比をKとして全漁船について引き延ばしを行い，全漁船の有効漁獲強度（f_T）とした。また，標本船の操業範囲は小型底曳網漁場を充分にはカバーしていないので，平均密度指数（ϕ'）に，漁場面積（A′= 34.1平方海里）を乗じて，この漁場における資源量指数（P_T）とした。これらの値を Table 2 に示した。以下の分析には，この値を使用した。

次に，資源量指数（P_T）について，2期移動平均（$\bar{P}_T$）を求め平滑化した。

$$\bar{P}_{T \cdot i}=(P_{T \cdot i}+P_{T \cdot (i+1)})/2$$

$\bar{P}_{T \cdot i}$ を i 期の終わりの資源量指数および（$i+1$）期の始めの資源量指数とした。この指数（$\bar{P}_T$）から5日期ごとの全変化率（S）を求め，次式から全変化係数（V）を求めた。

Table 1. Catch statistics by the sample small trawlers.

Month	Period*	A (mile^2)	C (Number of prawn)	X (mile)	P	ϕ'	X	r	f
June	1	11.7	102	13.5	82.2	7.0	14.5	1.076	1.24
	2								
	3								
	4	18.5	514	51.3	182.0	9.8	52.2	1.018	2.82
	5	11.6	76	14.9	58.8	5.1	15.0	1.005	1.29
	6	3.0	121	4.5	80.0	26.7	4.5	1.011	1.52
July	7	3.3	262	7.9	120.3	36.4	7.2	0.911	2.18
	8	4.2	646	21.1	125.0	29.8	21.7	1.029	5.17
	9	16.4	1,232	52.7	270.7	16.5	74.7	1.417	4.55
	10	9.8	164	25.6	57.2	5.8	28.1	1.096	2.86
	11	17.2	273	43.1	121.3	7.1	38.7	0.897	2.25
	12	30.0	829	86.6	201.4	6.7	123.5	1.426	4.12
Aug.	13	3.8	70	7.5	35.4	9.3	7.5	1.002	1.98
	14	15.0	2,825	111.8	467.5	31.2	90.6	0.811	6.04
	15	27.9	1,284	117.3	278.1	10.0	128.8	1.098	4.62
	16	13.3	210	29.9	82.5	6.2	33.9	1.134	2.55
	17	38.9	866	93.8	309.4	8.0	108.8	1.160	2.80
	18	31.7	778	67.8	361.6	11.4	68.2	1.005	2.15
Sept.	19	44.7	2,753	178.5	457.9	10.2	268.8	1.506	6.01
	20	24.2	463	42.5	185.4	7.7	60.4	1.422	2.50
	21	40.2	1,417	132.7	384.0	9.6	148.3	1.118	3.69
	22	7.8	60	9.4	51.2	6.6	9.2	0.976	1.18
	23	37.4	1,382	163.8	260.1	7.0	198.8	1.214	5.31
	24	44.8	1,774	175.3	412.7	9.2	192.5	1.098	4.30
Oct.	25	33.3	651	84.4	250.9	7.5	86.3	1.023	2.59
	26	31.2	359	53.0	234.6	7.5	47.8	0.901	1.53
	27	29.8	583	92.2	157.0	5.3	110.6	1.200	3.71
	28	38.1	522	103.1	184.7	4.8	107.6	1.044	2.82
	29	25.1	292	61.3	122.1	4.9	60.1	0.980	2.39
	30	5.8	1	7.7	0.8	0.1	7.5	0.978	1.30

A : area of operated blocks
C : catch in number by sample boats
X : hauling distance
P : relative index of population size
ϕ' : average relative index of population density
X : effective effort
f : effective overall fishing intensity

* One period consists of 5 days.

Table 2. Estimation of the effective overall fishing intensity and the relative index of population size for the whole boats operating in the study area.

Period	C_T	Sample boat			K	Total boat		P_T
		C	ϕ'	$\tilde{X}$		$\tilde{X}_T$	f_T	
4	12,846	514	9.8	52.2	25.0	1,305	38.3	334
5	9,652	76	5.1	15.0	127.0	1,905	55.9	174
6	14,256	121	26.7	4.5	117.8	530	15.5	910
7	12,572	262	36.4	7.2	48.0	345	10.1	1,241
8	13,907	646	29.8	21.7	21.5	467	13.7	1,016
9	22,311	1,232	16.5	74.7	18.1	1,353	39.7	563
10	12,392	164	5.8	28.1	75.6	2,123	62.3	198
11	10,609	273	7.1	38.7	38.9	1,504	44.1	242
12	17,464	829	6.7	123.5	21.1	2,602	76.3	228
13	4,266	70	9.3	7.5	60.9	457	13.4	317
14	28,322	2,824	31.2	90.6	10.0	909	26.6	1.064
15	19,873	1,284	10.0	128.8	15.5	1,993	58.5	341
16	3,738	210	6.2	33.9	17.8	603	17.7	211
17	13,392	866	8.0	108.8	15.5	1,683	49.3	273
18	7,927	778	11.4	68.2	10.2	695	20.4	389
19	12,396	2,753	10.2	268.8	4.5	1,210	35.5	348
20	2,714	463	7.7	60.4	5.9	354	10.4	263
21	14,128	1,417	9.6	148.3	10.0	1,479	43.4	327
22	310	60	6.6	9.2	5.2	48	1.4	225
23	15,273	1,382	7.0	198.8	11.1	2,197	64.4	239
24	14,481	1,774	9.2	192.5	8.2	1,571	46.1	314
25	6,723	651	7.5	86.3	10.3	891	26.1	256
26	4,290	359	7.5	47.8	11.9	571	16.8	256
27	8,325	583	5.3	111.0	14.3	1,585	46.5	181
28	7,946	521	4.8	107.6	15.3	1,641	48.1	164
29	4,017	292	4.9	60.1	13.8	827	24.2	167

C_T : total catch in number
K : ratio of C_T to C
$\tilde{X}_T$: total offective effort
f_T : total effective overall fishing intensity
P_T : estimated relative index of population size

$$V = F + M - \alpha = -\log_e S$$

ここで，Fは漁獲死亡係数，Mは自然死亡係数（逸散係数を含む），αは加入係数である。Table 3 はこれらの結果を示す。この結果から，以下の計算に使える期間は，5～28期（6月20日～10月20日）である。

5日期ごとにまとめた有効漁獲強度（f_T）と，全変化係数（V）との関係を Fig. 2 に示した。漁獲能率をqとすると，

$$F = q \times f_T$$

である。

全減少係数をZとすると，

加入がない場合（$\alpha = 0$），

Table 3. Estimation of total change coefficient from relative index of population size.

Period	P_T	$\bar{P}_T$	S	V
4	334			
		254		
5	174		2.136	−0.759
		543		
6	911		1.983	−0.685
		1,076		
7	1,241		1.049	−0.048
		1,129		
8	1,016		0.700	0.357
		790		
9	563		0.482	0.730
		381		
10	198		0.578	0.548
		220		
11	242		1.070	−0.068
		236		
12	229		1.159	−0.148
		273		
13	317		2.529	−0.928
		691		
14	1,064		1.017	−0.017
		703		
15	341		0.393	0.934
		276		
16	211		0.877	0.131
		242		
17	273		1.368	−0.313
		331		
18	389		1.113	−0.107
		369		
19	348		0.829	0.187
		306		
20	263		0.966	0.035
		295		
21	327		0.936	0.067
		276		
22	225		0.841	0.174
		232		
23	239		1.192	−0.175
		277		
24	314		1.031	−0.030
		285		
25	256		0.898	0.107
		256		
26	256		0.854	0.158
		219		
27	181		0.789	0.236
		173		
28	164		0.959	0.041
		166		
29	167			

$\bar{P}_T$: 2 term's moving average of P_T
S : rate of total change
V : coefficient of total change

$$V = F + M = Z$$
$$Z = q \times f_T + M$$

すなわち，加入がない場合，f_T と V（=Z）の関係は，傾き q，切片をMとする直線となり，各点の上限に位置するはずである。また，加入があると，

$$V = Z - \alpha$$
$$= q \times f_T + M - \alpha$$

であるので，f_T に対応するVの位置は，加入がない場合に求められた直線から，α だけ下にある。

以上のことを念頭において，次に述べる2種類の数学的モデルを考えて，資源特性値を計算した。

(1) 各5日期を移動期と滞留期に分けた場合

Fig. 2 に示した各5日期の与える点について，資源量指数の変化（Fig. 3 または，Fig. 4）および標本船の操業位置等を参考にして[4]，時期8，9，15は，加入のない移動期と考えて直線(a)を，また，時期16,

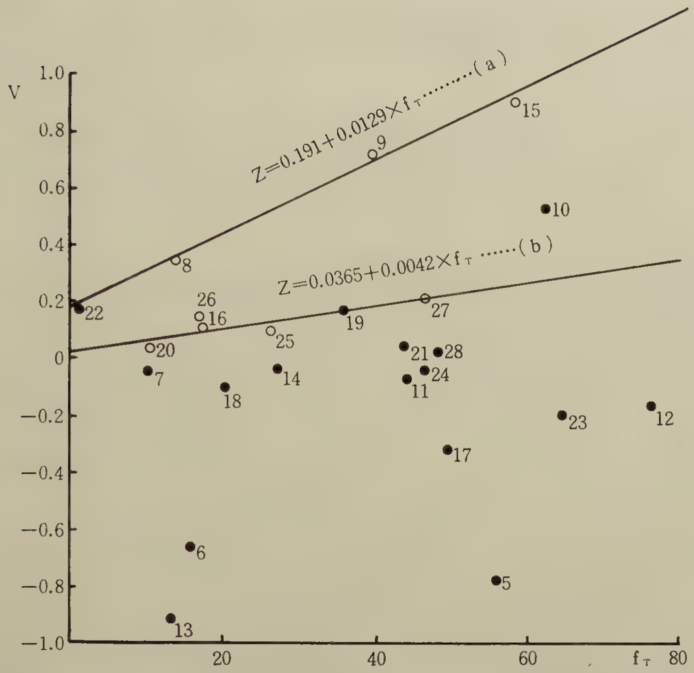


Fig. 2. The regression of the effective overall fishing intensity (f_T) on the coefficient of total change (V).
Numerals in the graph indicate serial numbers of 5 day period.
The regression lines (a) and (b) were fitted to the piriods shown by open circles.
The totlal mortality coefficient (Z) will coincide with the total change coefficient (V) when there are no recruitment.

20，25，26，27は，加入のない滞留期と考え直線(b)をそれぞれ最小自乗法により当てはめた。これら２本の直線の回帰係数より，

移動期　$F=q\times f_T=0.0129\times f_T$　　　$M=0.191$

滞留期　$F=0.00424\times f_T$　　　$M=0.0365$

を得る。

漁獲能率ｑが時期により変化する理由としては，移動期には何らかの理由で漁獲されやすくなるとか，漁船の操業形態が変化するとかが考えられる。また，逸散係数については，加入がない（$\alpha=0$）の場合の移動期と滞留期の漁獲死亡係数以外の減少係数の差であるとも考えられるが，この差が実際に逸散係数を示すのか，それとも移動期の特異な生態により自然死亡係数が増加しているのかがあきらかでない。したがって，以下の解析にあたっては，逸散係数は，自然死亡係数（M）の中に含めて処理した。

標本船の操業位置[4]，資源量指数の変化および f_T と V の関係図における点の位置などから判断して，全ての５日期を移動期，滞留期に分け，さらに加入の有無を組み合わせて，次の４種類に分類した。

(i)　移動期で加入がある…… 6，7，10，14，17，18，24

(ii)　移動期で加入がない…… 8，9，15

Table 4. Change of population in number in each 5 day period. (Model-1)

Month	Period	q ($\times 10^{-2}$)	M	V′	α	F	S′	D	E	R	No	Ne	Nd	Nr
June	5	0.424	0.0365	−0.755	1.028	0.236	2.128	0.055	0.353	1.536	27332	58163	1490	41972
	6	1.29	0.191	−0.688	1.081	0.203	1.989	0.275	0.291	1.555	48907	97284	13429	76064
July	7	1.29	0.191	−0.048	0.370	0.131	1.049	0.196	0.134	0.379	94009	98631	18384	35583
	8	1.29	0.191	0.368	0	0.177	0.692	0.160	0.148	0	93978	65057	15011	0
	9	1.29	0.191	0.703	0	0.512	0.495	0.137	0.368	0	60706	30070	8325	0
	10	1.29	0.191	0.550	0.443	0.802	0.577	0.147	0.617	0.341	20087	11591	2950	6845
	11	0.424	0.0365	−0.066	0.289	0.187	1.068	0.038	0.193	0.299	54913	58654	2072	16422
	12	0.424	0.0365	−0.152	0.512	0.323	1.164	0.039	0.349	0.553	49994	58207	1971	27646
Aug.	13	0.424	0.0365	−0.927	1.020	0.057	2.526	0.060	0.094	1.679	45495	114906	2734	76408
	14	1.29	0.191	−0.016	0.551	0.344	1.016	0.192	0.347	0.555	81726	83044	15727	45368
	15	1.29	0.191	0.945	0	0.754	0.389	0.123	0.488	0	40741	15837	5031	0
	16	0.424	0.0365	0.112	0	0.075	0.894	0.035	0.071	0	5266	47110	1819	0
	17	1.29	0.191	−0.313	1.141	0.637	1.368	0.224	0.748	1.340	17914	24502	4016	23996
	18	1.29	0.191	−0.112	0.565	0.263	1.118	0.202	0.278	0.598	28513	31883	5759	17056
Sept.	19	0.424	0.0365	0.187	0	0.150	0.829	0.033	0.137	0	90320	74915	3007	0
	20	0.424	0.0365	0.081	0	0.044	0.923	0.035	0.042	0	64123	59157	2249	0
	21	0.424	0.0365	0.220	0	0.184	0.802	0.033	0.165	0	85622	68693	2805	0
	22	0.424	0.0365	0.042	0	0.006	0.958	0.036	0.006	0	53722	51492	1920	0
	23	0.424	0.0365	−0.178	0.488	0.273	1.195	0.040	0.299	0.534	51077	61052	2041	27287
	24	1.29	0.191	−0.036	0.821	0.595	1.036	0.194	0.605	0.836	23926	24791	4650	19996
Oct.	25	0.424	0.0365	0.147	0	0.111	0.863	0.034	0.103	0	65236	56301	2214	0
	26	0.424	0.0365	0.108	0	0.071	0.898	0.035	0.067	0	63749	57251	2206	0
	27	0.424	0.0365	0.233	0	0.196	0.792	0.033	0.175	0	47498	37626	1547	0
	28	0.424	0.0365	0.240	0	0.204	0.786	0.032	0.181	0	43883	34513	1424	0

q : catchability coefficient
M : natural mortality coefficient (including dispersion coefficient)
V′ : adjusted coefficient of total change
α : coefficient of recruitment
F : coefficient of fishing mortality
S′ : adjusted rate of total change
D : rate of natural mortality
E : rate of exploitation
R : rate of recruitment
No : population in number at the beginning of each period
Ne : population in number at the end of each period
Nd : natural mortality in number (including dispersion)
Nr : recruitment in number

(iii) 滞留期で加入がある…… 5, 11, 12, 13, 23

(iv) 滞留期で加入がない……16, 19, 20, 21, 22, 25, 26, 27, 28

加入がない場合の全減少係数（Z）は，

$$Z = F + M = q \times f_T + M$$

で計算した。ただし，移動期と滞留期とでは，qおよびMの値が異なる。

加入がある場合にも，FおよびMの値は，移動期と滞留期とでは異なるが，加入係数αは，

$$\alpha = (F + M) - V = (q \times f_T + M) - V$$

から求めた。

すなわち，加入のない場合は上で求めたZを，加入のある場合はVを，各5日期の調整された全変化係数（V′）とした。

各5日期のF，M，α，V′ を上述を上述のように定めると，各資源特性値は各5日期ごとに次の式により計算できる[6]。結果を Table 4 に示す。

調整された全変化率	$S' = e^{-V'}$
自然死亡率（逸散率を含む）	$D = \frac{M}{V'}(1 - S')$
漁　獲　率	$E = \frac{F}{V'}(1 - S')$
加　入　率	$R = \frac{\alpha}{V'}(1 - S')$
始めの資源尾数	$No = C_T / E$
終りの資源尾数	$Ne = No \times S'$
自然死亡尾数（逸散尾数を含む）	$Nd = No \times D$
加入尾数	$Nr = No \times R$

また，資源量指数（$\bar{P}_T$）は資源尾数(N)に比例する。

$$N = b \times \bar{P}_T$$

$$(\text{ただし，} b = \Sigma \bar{P}_{T \cdot i} \times N_i) / \Sigma(\bar{P}_{T \cdot i})^2 \;)$$

Table 4 について計算すると，

$$N = 103.9 \times \bar{P}_T$$

または，$\bar{P}_T = 0.00962 \times N$

となる。

以上の解析によって得られた各5日期ごとの資源量指数と，資源尾数および加入尾数の計算値の変化を Fig. 3 に示した。

(2)　移動期と滞留期とを区別しない場合

上記(1)のモデルに用いた移動期における f_T とZの関係の直線(a)は，3個の点から求められている。これらの点を与えた時期の標本船の操業状況を検討してみると，いずれも少数の漁船が干潟周辺部で，沖合へ移動する前の体長10cm前後の小型クルマエビを多獲しており[4]，むしろ例外的な場合であるとも考えられる。また，モデル(1)において直線(a)から得られた自然死亡係数M= 0.191は，坪刈り調査による干潟生息段階の自然死亡係数等[3]から考えても，値が大きすぎる。そこで，直線(b)から得られた，M=0.0365，q =0.00424を，全期間にわたって使用することにした。各5日期を次の2種類に分類した。

5日期区分

(i)　加入がある……5, 6, 7, 11, 12, 13, 14, 17, 18, 23, 24

(ii)　加入がない……8, 9, 10, 15, 16, 19, 20, 21, 22, 25, 26, 27, 28, 29

各5日期ごとのF，M，α，V′の定め方は，(1)のモデルと同様に行ない，各資源特性値も同様に計算し，結果を Table 5 に示した。

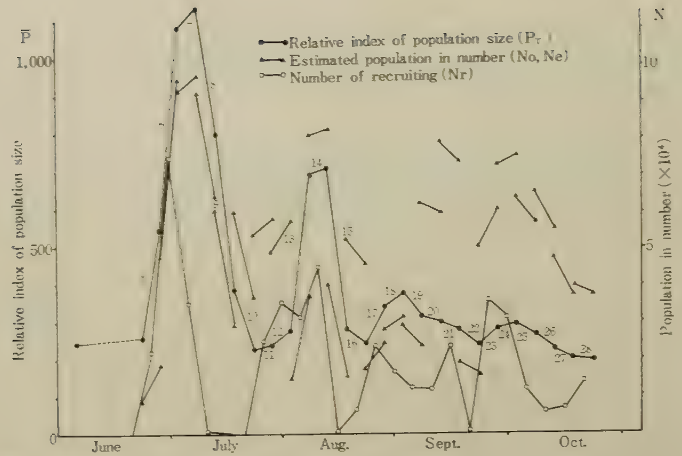


Fig. 3. Fluctuations in the relative index of population size, estimated population number and the number of recruiting population. (Model-1) Numerals in the graph indicate serial numbers of the 5 day period.

Table 5. Change of population in number in each 5 day period. (Model-2)

Month	Period	V′	α	F	S′	D	E	R	No	Ne	Nd	Nr
June	5	−0.755	1.028	0.236	2.128	0.055	0.353	1.536	27332	58163	1490	41972
	6	−0.688	0.791	0.067	1.989	0.052	0.096	1.137	148799	295981	7812	169248
July	7	−0.048	0.127	0.043	1.049	0.037	0.044	0.131	286018	300082	10694	37327
	8	0.095	0	0.058	0.910	0.035	0.055	0	250732	228100	8732	0
	9	0.205	0	0.168	0.815	0.033	0.152	0	146721	119562	4843	0
	10	0.300	0	0.264	0.741	0.032	0.228	0	54417	40309	1716	0
	11	−0.066	0.289	0.187	1.068	0.038	0.193	0.299	54913	58654	2072	16422
	12	−0.152	0.512	0.323	1.164	0.039	0.349	0.553	49994	58207	1971	27646
Aug.	13	−0.927	1.020	0.057	2.526	0.060	0.094	1.679	45495	114906	2734	76408
	14	−0.016	0.166	0.113	1.016	0.037	0.114	0.167	248646	252657	9149	41482
	15	0.284	0	0.248	0.753	0.032	0.216	0	92127	69329	2927	0
	16	0.112	0	0.075	0.894	0.035	0.071	0	52666	47110	1819	0
	17	−0.313	0.559	0.209	1.368	0.043	0.246	0.656	54501	74547	2336	35771
	18	−0.112	0.235	0.086	1.118	0.039	0.091	0.248	86750	97002	3350	21532
Sept.	19	0.187	0	0.150	0.829	0.033	0.137	0	90320	74915	3007	0
	20	0.081	0	0.044	0.923	0.035	0.042	0	64123	59157	2249	0
	21	0.220	0	0.184	0.802	0.033	0.165	0	85622	68693	2805	0
	22	0.042	0	0.006	0.958	0.036	0.006	0	53722	51492	1920	0
	23	−0.178	0.488	0.273	1.195	0.040	0.299	0.534	51077	61052	2041	27287
	24	−0.036	0.267	0.195	1.036	0.037	0.199	0.272	72794	75424	2705	19815
Oct.	25	0.147	0	0.111	0.863	0.034	0.103	0	65236	56301	2214	0
	26	0.108	0	0.071	0.898	0.035	0.067	0	63749	57251	2206	0
	27	0.233	0	0.196	0.792	0.033	0.175	0	47498	37626	1547	0
	28	0.240	0	0.204	0.786	0.032	0.181	0	43883	34513	1424	0
	29	0.139	0	0.103	0.870	0.034	0.096	0	41885	36442	1427	0

The value of M=0.0365 and q=0.00424 were applied for every period. Symbols are the same in table 4.

この場合は，

$$N = 232.6 \times P_T$$

$$\bar{P}_T = 0.00430 \times N$$

となる。この結果を Fig. 4 に示す。

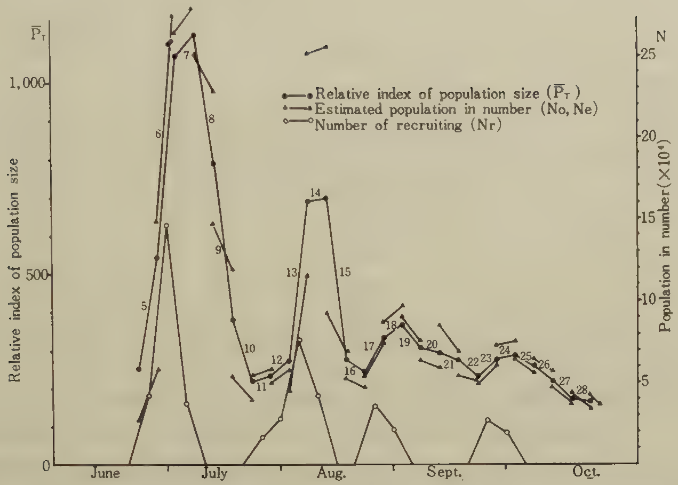


Fig. 4. Fluctuations in the relative index of population size, estimated population in number and the number of recruiting population. (Model－2) Numerals in the graph indicate serial numbers of the 5 day period.

なお，以上の計算に用いた漁獲尾数は，河原津漁協の水揚統計のみであり，前述のように，この水域の漁獲量のおよそ80%を占めていると考えられる。したがって，実際の有効漁獲強度 f_T は1.25倍となる。このため漁獲能率 q は 0.8 倍，尾数の換算では1.25倍とする必要がある。ただし，この補正値は，ここでは使用していない。

以上の結果を，土井ほか[6]が求めた資源特性値と比較して，Table 6 に示した。なお，この比較にあたっ

Table 6. The comparison of the population parameters estimated by Model (1) and (2) with those calculated by the Model of Doi et al (1972).

Coefficient \ Type of the Model	Model by Doi et al (1972)	Model (1) Migratory stage	Model (1) Non-migratory stage	Model (2)
Natural mortality (M)	0.211	0.191	0.0365	0.0365
Catchability (q)	0.00682	0.0129	0.00424	0.00424
Recruiting (α)	0.526	0～1.141	0～1.028	0～1.028

て，両者の漁場面積の解釈の差による違いは，本報告の尺度に換算し統一した。すなわち，土井ほかは，漁場面積を50平方海里と仮定したが，本報告では，34.1平方海里とした。そのための補正として，前者の求めた f_T，q は，$f'_T = f_T/0.682$，$q' = 0.682 \times q$ として補正した f'_T，q' を用いた。（0.682＝（34.1平方海里/50平方海里））

考　　察

土井ほか[6]は，1970年９月～11月の間，同海域での資源解析を行ったが，本報告では，1971年６月～10月の期間について，ほぼ同様な方法で解析を行った。この期間は，河原津の小型底曳網が，クルマエビを主要な漁獲対象としている時期でもある。まとめ方の違いは，漁場面積を実体に合わせて変更したこと，加入係数の変化を考慮した数理モデルを用いたことである。クルマエビの沖合漁場への加入は，干潟から単調に拡散するのではなく，体長11～13cm位から急激におこる[5]。このように間けつ的な移動がおこるため，加入係数は一定ではないと考える方が現実的であろう。

数理モデルの作り方により，数値に当然差が出る。そのいずれがより正しいかの最終的な判断はできないが，モデル(1)における移動期，滞留期の区別をする必然性については，さらに別の調査が必要であろう。また，資源量指数の変化と，モデル(1)による資源尾数の推定値の一致がよくない。(Fig. 3)

他方，モデル(2)による計算では，土井ほかの報告や，この資料における８，９，15期のような，急激な資源量水準の変化（いわゆる移動期）をうまく説明できない。

Table 7 に，モデル(1)およびモデル(2)により計算された加入尾数，資源尾数，自然死亡尾数（逸散尾数を

Table 7. Estimations of population size, recruitment and naturl mortality in the two different models. (number of prawns)

		Model (1)	Model (2)
Total catch		227, 267	
Population in each period	Initial	27, 332	27, 332
	Last	34, 513	36, 442
	Mean	54, 726	94, 130
Recruitment	1 st	(Period 5– 7) 153, 619	(Period 5– 7) 248, 547
	2 nd	(Period 10–14) 172, 689	(Period 11–14) 161, 958
	3 rd	(Period 17–18) 41, 052	(Period 17–18) 57, 303
	4 th	(Period 23–24) 47, 283	(Period 23–24) 47, 102
	Total	414, 643	514, 910
Natural mortality		122, 781	85, 190

含む）を示す。操業資料収集の精度と，含まれているであろう相当な誤差を考えれば，この２種のモデルによる計算値はよく一致しているといえよう。すなわち，1971年６月～10月の期間には，調査範囲の小型底曳網漁場では，４回の加入が行われ，その合計は40～50万尾であり，そのうち約30万尾が漁獲され，８～12万尾が自然死亡または逸散したと推定される。

要　　約

燧灘西部小型底曳網漁場におけるクルマエビ資源の解析，とくに加入量について検討した。河原津における標本船の操業記録と，全船の漁獲尾数の資料を，５日期ごとに整理し，有効漁獲強度を求めた。操業記録

から求めた平均密度指数は，漁場面積を34.1平方海里として，資源量指数に換算した。次に，資源量指数の変化から全変化係数を求め，有効漁獲強度との関係を図解し，その解釈から二つの数理モデルを考え資源特性値を計算した。ただし，自然死亡係数(M)には逸散係数も含めた。

1) 移動期と滞留期に分けて，漁獲能率(q)およびMを求めた。

移動期：q＝0.0129　　M＝0.191

滞留期：q＝0.00424　　M＝0.0365

2) 全ての時期を滞留期として考え，モデル1)の滞留期の係数を用いた。

次に，加入係数(α)は，全変化係数(V)と，上記の係数により定められる全減少係数(Z)との差として求め，各資源特性値を計算した。両モデルにより求められた数値は，ほぼ一致しており，次のように考えられる。1971年6月～10月の期間には，この漁場には4回の加入が行われ，その合計は40～50万尾であり，そのうち約30万尾が漁獲され，8～12万尾が自然死亡または逸散した。

文　献

1) 倉田博，石岡清英，仁科重己，1971：放流種苗の減耗に関する研究．浅海別枠備後灘，昭45研究成果，5～32.

2) 長谷川彰，山口義昭，石岡清英，1971：種苗放流の生産効果に関する研究．同誌，33～51.

3) 倉田博，石岡清英，仁科重己，河野慈敬，1972：放流種苗の減耗に関する研究―1，放流方法に関する研究．浅海別枠備後灘，昭46研究成果，16～25.

4) 長谷川彰，高尾亀次，石岡清英，外間源治，河野慈敬，1972：種苗放流の生産効果に関する研究―1，漁業生産効果．同誌，121～148.

5) ――，――，――，――，――，1973：減耗要因の解明に関する研究―2，西条漁場における種苗放流の生産効果．浅海別枠備後灘，昭47研究成果，8～33.

6) 土井長之，金容文，高尾亀次，石岡清英，岡田啓介，1972：燧灘底曳漁場におけるクルマエビの資源解析．東海水研報，69，45～54.

7) ――，1971：マッコウ鯨の資源診断法．同誌，66，89～143.

8) 松浦秀喜，土井長之，1974：山口県外海域のマダイ資源研究―Ⅱ．仙崎湾・深川湾マダイ当歳魚の資源解析．同誌，80，11～28.

9) 田中昌一，1957：資源量の相対指数と有効漁獲努力量．同誌，17，1―13

Bull. Nansei Reg. Fish. Res. Lab. (8) 81～100 (1975)

広島県中部海域におけるマダイ未成魚の年令と成長

国 行 一 正・矢 野 實・川 西 正 衛*

The Age Determination and Growth of Immature Red Sea Bream, *Chrysophrys major* TEMMINCK et SCHLEGEL, in the Central Waters of Hiroshima Prefecture

Kazumasa KUNIYUKI, Minoru YANO and Masae KAWANISHI

Age determination of Red Sea Bream has been studied by a few investigators. The studies, however, did not focus on the early stages of this important commercial species in the south-western half of Japan coast.

The present report is prepared for answering, firstly, the progress of recent studies related to mass releasing of the juveniles of red sea bream and, secondly, the age and growth study in the state of depleation of this resource in the Seto Inland sea.

The following relations of age and growth are summarized:

$$l_t = 484.50 \cdot \{1 - e^{-0.18 \cdot (t+0.47)}\}$$

$$W_t = 2368.22 \cdot \{1 - e^{-0.18 \cdot (t+0.417)}\}^{2.84}$$

Where l : Fork length

W : Body weight

t : Age

瀬戸内海重要資源の一つであるマダイの漁獲量は，1950年代前半に5,000トン台の漁獲水準を示したがその後は漸次減少傾向を示し，1970年代前半には2,000トン台の漁獲水準に止まっている。この資源の培養をはかるための方策の一つとして，人工生産した種苗を天然海域に放流し有効に漁業資源に添加する事業が国と県の補助事業（魚類放流技術開発）として行なわれ，関係諸機関の協同によって取組まれつつある。

この放流種苗が漁業生産（漁獲）の中にもたらす効果の判定は容易ではないが，放流水域におけるマダイ個体群の発育成長段階別（幼魚，未成魚，成魚）にみた資源生物学的特性，すなわち年令，成長，成熟，分布移動，洄游，生残り，漁獲等に関する知見の綜合的検討にまたなければならない。

瀬戸内海中央部，広島県と愛媛県にまたがる芸予諸島は，瀬戸内海でも特徴的な多島海域であり，マダイ個体群の再生産補給海域として重要な役割をもっている。この海域では，マダイ種苗の効果的な放流に関して種々の試みが行なわれている。広島県音戸町倉橋漁場では，音響馴致によるマダイの飼い付け実験と馴致魚の放流が行なわれ，同豊浜町豊島漁場では，藻場周辺に人工組立魚礁を沈設し幼魚の生育環境を造成した場所に人工種苗の放流を実施している。更に，三原水道の細ノ州漁場では，天然浮游幼稚仔の着底添加機構の解明と，定着魚の生残り過程を把握するため，人工種苗の添加放流実験が行なわれている。

筆者らは，これら種苗放流とその追跡調査により，各種の漁業生物学上の知見を得ようと考えているが，その一環として前述の広島県中部海域におけるマダイ未成魚に焦点をしぼり，その年令と成長について検討

1975年8月15日受理　南西海区水産研究所業績第52号

＊　広島県水産試験場

を行なった。この研究は，魚類放流技術開発事業の中の資源生態調査の中で実施したものである。長期にわたる標本採集と多項目生物調査は広島県水産試験場川西正衛，年令査定と取まとめは南西海区水産研究所国行一正，矢野　実が分担した。

本文に入るに先だち，この研究の推進と発展の機会を与えられ，かつ有益な示唆をいただいた南西海区水産研究所長花村宣彦博士，論文の校閲と終始懇切なる指導と助言をいただいた同内海資源部長多々良薫博士に心から謝意を表します。また，困難な標本採集に当って絶大な協力をいただいた竹原市忠海漁業協同組合の関係各位，そしてこの研究に用いた鱗の標本作製に当っていただいた竹下涼子さんに厚く御礼申しあげます。

材料および方法

広島県中部海域のマダイは，主として一本釣，延縄，ローラー吾智，刺網，桝網によって漁獲される。本研究で使用した標本は，いずれも1973年5月から1974年4月の間に忠海漁業協同組合に水揚げされた刺網による漁獲物である。調査各月において，尾叉長300㎜以下の4才未満と考えられるものを50～60尾測定したが100尾前後測定した月もある。しかし，9月以降は，カスゴと呼ばれる100㎜前後のものが漁獲対象となり検鱗は行なったが輪紋の形成が見られず年令査定のための供試標本には加えなかった。各月別の標本数は，表1に示す通りである。

Table 1. Conditions of specimens used in the experiment

Date of catch		Numbers of specimens	Ranges of fork length (mm)	collective location
May	24, 1973	92	89—298	Tadanoumi
June	28, 〃	42	124—268	〃
July	26, 〃	61	134—301	〃
Aug.	25, 〃	49	142—314	〃
Sept.	26, 〃	87	144—285	〃
Oct.	30, 〃	32	163—334	〃
Nov.	28, 〃	10	139—204	〃
Dec.	19, 〃	42	160—269	〃
Feb.	5, 1974	23	149—269	〃
Apr.	4, 〃	11	155—285	〃
Total		449		

標本は実験室にもち帰り精密測定を行ない，全長・尾叉長・体長・肛門長・頭長・体高・眼径・体重・生殖腺重量等を計測し採鱗を行なった。採鱗部位は胸鰭付根から後方の5～6枚目附近のもの4～5枚を採取した。供試鱗は5％の苛性カリ液に一昼夜浸漬し，引続き一昼夜水洗をした後2枚のスライドグラスにはさ

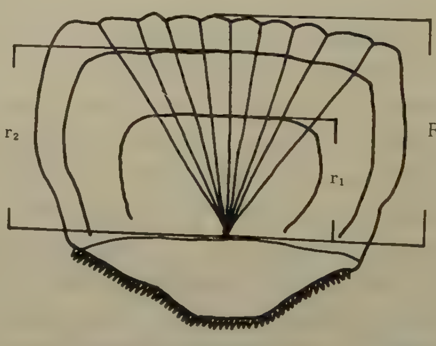


Fig. 1. Diagram showing the method used to measure scale length and ring diameter
R = Scale length, r_1 = Ring diameter of first ring, r_2 = Ring diameter of second ring

んでプレパラート標本を作製した。輪紋の測定は万能投影機を用いて10倍に拡大して測定した。鱗長（R）は図1に示すように鱗の中心（focus）から被覆部と露出部の境界線に引いた直線に対し，被覆部の縁辺に向って垂直に測り，同様にそれぞれの輪紋半径（r_n）を測定した。輪紋は最も内側のものを第1輪紋とし，外側に向って第2，第3，……第 i 輪紋とし中心からの長さをもってそれぞれの輪紋の大きさとした。

結　　　　果

鱗長と尾叉長との関係　　1973年5月の92個体の鱗長（R）と尾叉長（FL）の関係を図2に示した。R

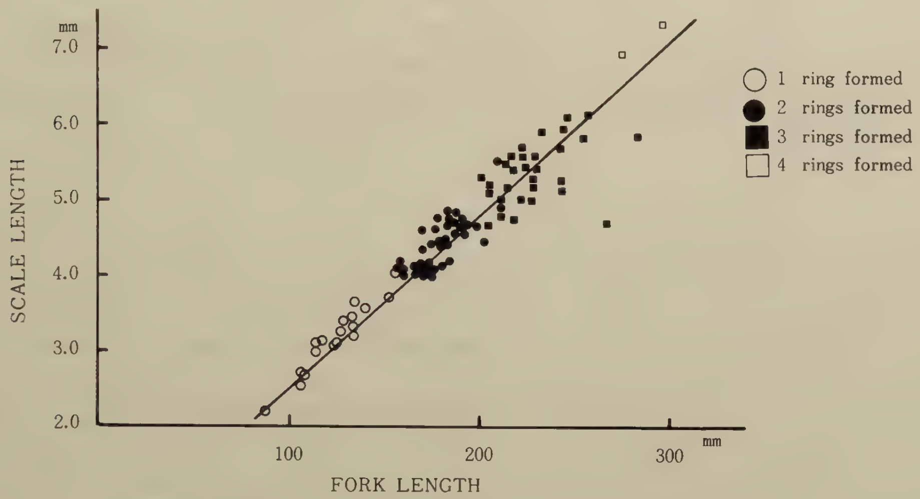


Fig. 2. Relation between scale length and fork length

（mm）に対するFL（mm）の回帰式を最小二乗法で求めると，

$$FL = -33.93 + 48.54R \cdots\cdots(1)$$

が得られる。相関係数 0.946 を示し分散も小さく，鱗の成長と魚体の成長の間の相関性が高いことを示している。特に尾叉長200mmまでの幼魚期から未成魚期には，この傾向が著じるしい。

輪紋とその形成時期　　輪紋等の標示を年令形質として用いて良いかどうかは，その標示が毎年どの個体にも必らず特定の時期に出現することが必要である。ここでは，1973年8月の61個体について，輪群別に鱗長Rに対する輪紋 r_n の値を図3に示した。この図に明らかなように，各輪群とも一定の幅の中に分布し各輪径は重なることなく分離している。

また，各月毎に輪紋半径 r_n と尾叉長FLのそれぞれの平均値を全期間について求めた値を図4に示した。このを結果見ると，各輪群毎に平行に引ける直線にそって分布しており，少くとも若年期に形成される輪紋では，その半径の変動幅が小さく，隣接する輪紋の輪径分布は明らかに分離して重なることはない。

つぎに輪紋の形成時期について検討した。即ち鱗長Rと最外輪紋径 r_n の差で示される縁辺部の成長（$R-r_n$），および最外輪紋径（r_n）とその前年輪紋径（r_{n-1}）との差を求め，各輪群別月別に縁辺成長率（$R-r_n/r_n-r_{n-1}$）を計算してその結果を図5に示した。各輪群とも相似した傾向を示しているが，いま代表的な傾向を知るために2輪群の値だけを実線で結んだ。縁辺成長率は5月に最も小さく，最も大きい値は4月に見られる。この結果は年1回，4月から5月にかけて形成されることを示している。従って，この輪紋は年輪として採用してさしつかえないと考えられる。

輪紋形成時尾叉長（l_n）　さきに鱗長Rと尾叉長FLの関係式(1)を求めたが，この式に各個体の輪紋長

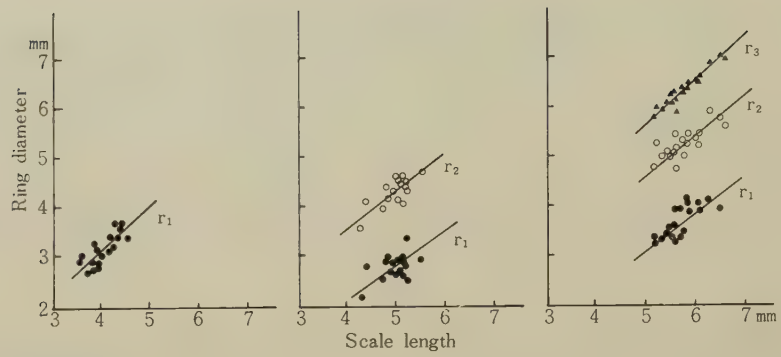


Fig. 3. Relation between scale length (R) and ring diameter (r_n) of scale by each specimen

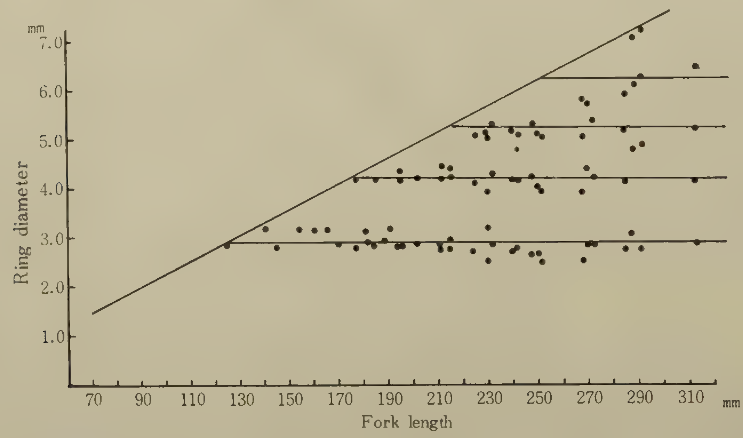


Fig. 4. Relation between representative value of ring diameter to fork length

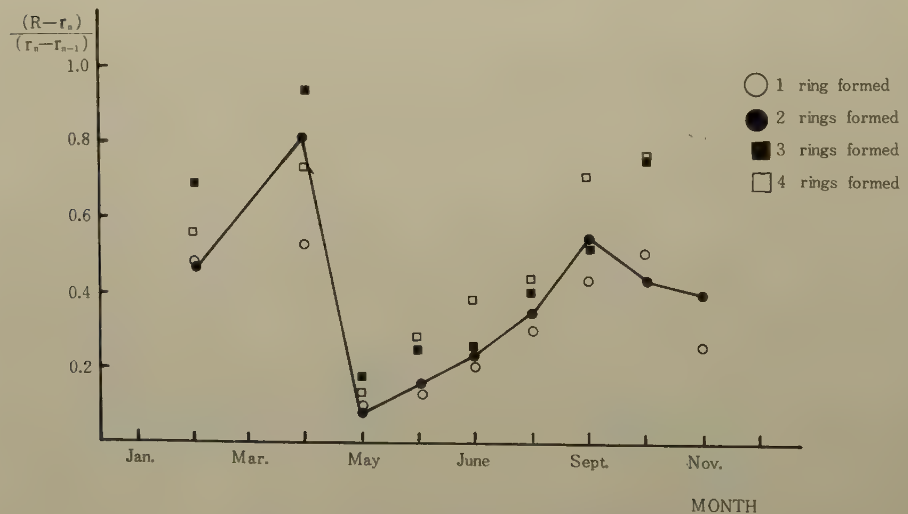


Fig. 5. Monthly changes of growth rate

（rn）を代入して各輪紋の形成時の尾叉長を求め，各輪群毎の尾叉長平均値を求め表２に示した。第１輪形成時の計算尾叉長を見ると，全体として明らかな Lee 氏現象が認められる。しかし，第２輪と第３輪形成時の尾叉長にはこの傾向は希薄であって，２輪魚と３輪魚の間には逆の結果も見られる。この Lee 氏現象の特徴が，刺網漁獲物に見られる特性かどうかは，広島県中部海域における他の漁具による漁獲物の結果と比較検討しなければならない。

尾叉長と体重との関係　全標本から任意に抽出して，尾叉長L（mm）と体重W（g）との関係を図６に示した。両者の関係式は次式で表わされる。

$$W = 5.60 \cdot 10^{-5} \cdot L^{2.84} \quad \cdots\cdots(2)$$

Table 2. Average of calculated fork length at the times of ring formation

Number of ring	Numbers of specimens	Calculated fork length (mm) l_1	l_2	l_3	l_4
1	204	111.93			
2	106	102.32	173.89		
3	113	102.05	176.49	229.03	
4	26	92.23	160.50	213.60	257.35
Average		98.87	170.29	221.32	257.35

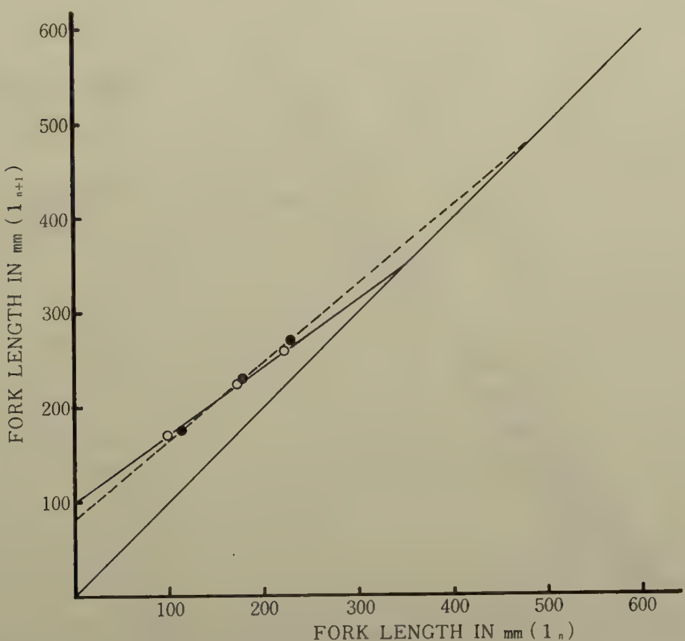


Fig. 7. Walford's growth transformation curves, based on the calculated fork length as shown in Table 2. Open circles show the average of calculated fork length. Closed circles indicate the size at the marginal ringes of each age-group.

考　　察

海老名（1940）は，マダイの成長には地域性があり，瀬戸内海では明石産マダイが最も成長がよく，ついで紀淡海峡，燧灘，豊予海峡（佐賀関），広島産の順となり広島産がもっとも成長が遅いことを報告してい

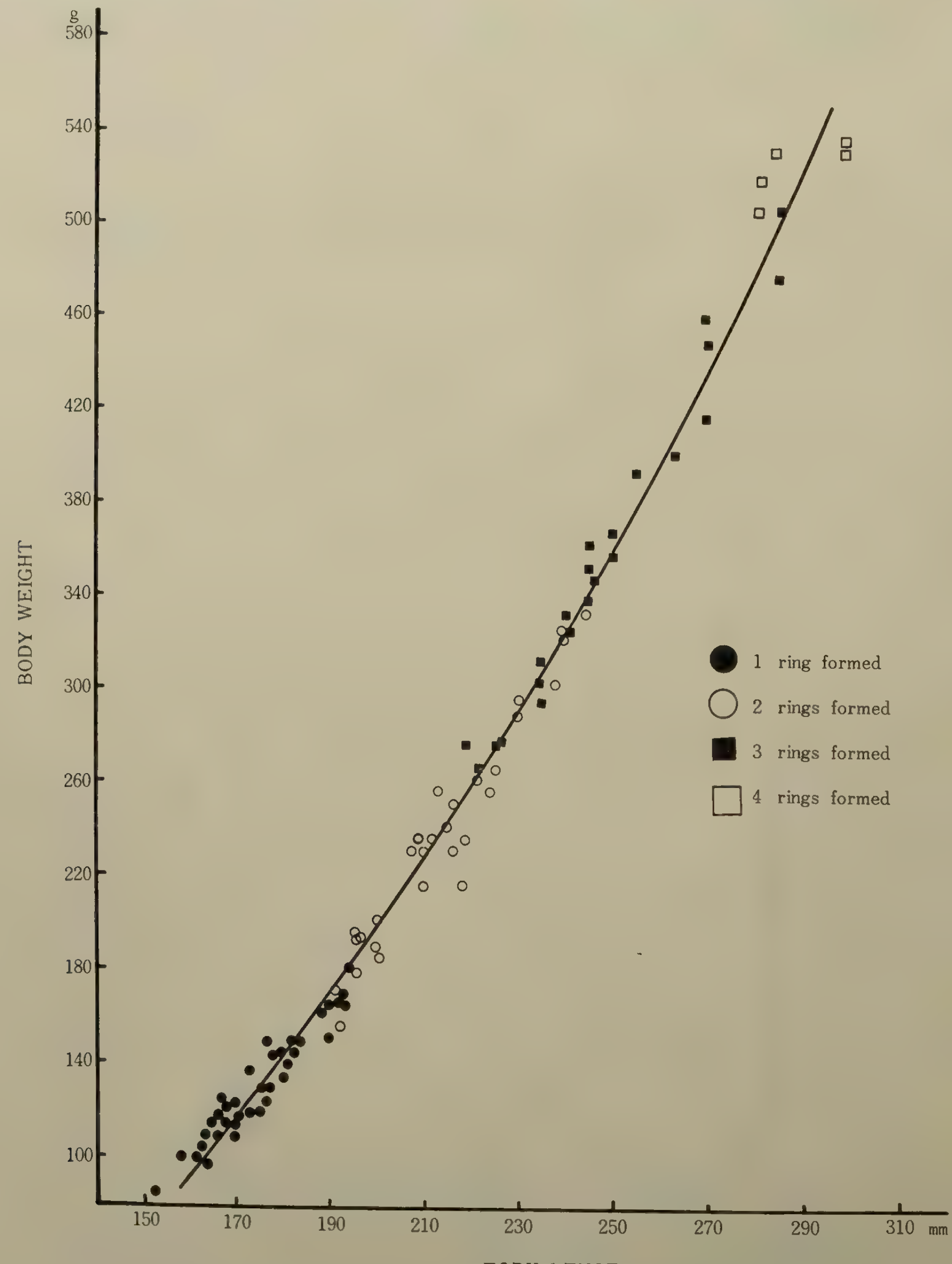


Fig. 6. Relation between fork length and body weight

る。また，三尾（1962）は，産卵期と初期成長量との海域傾斜を検討し，海域によって成長に相異があるのは，第1輪が形成されるまでの間の成長の違いに起因していると述べた。

広島県中部海域におけるマダイの年令査定の結果から，表2の輪紋形成時尾叉長は，それぞれ1，2，3，4才魚の輪紋形成時の尾叉長をあらわしているとみてよい。そこで，全標本の平均から得た値を定差図に示すと図7に実線で結んだ値となる。この定差方程式を求めると，

$$l_{t+1}=100.04+0.71l_t \quad \cdots\cdots(3)$$

を得る。これから，Bertalanffy の成長式を求めると，

$$l_t=346.41\cdot\{1-e^{-0.34(t-0.013)}\} \quad \cdots\cdots(4)$$

$$W_t=913.32\cdot\{1-e^{-0.34(t-0.013)}\}^{2.84} \quad \cdots\cdots(5)$$

を得る。この式から得た理論上の最大尾叉長は，346.41㎜となり実際的な値より可成り小さい値を示している。そこで表2に示した各輪紋数群別に得た最外輪径値，1輪群・111.93，2輪群・173.89，3輪群・229.03を用いて定差方程式を求め Bertalanffy の成長式を求めると次の各式を得る。

$$l_{t+1}=82.11+0.831l_t \quad \cdots\cdots(6)$$

$$l_t=484.50\cdot\{1-e^{-0.18\cdot(t+0.417)}\} \quad \cdots\cdots(7)$$

$$W_t=2368.22\cdot\{1-e^{-0.18\cdot(t+0.417)}\}^{2.84} \quad \cdots\cdots(8)$$

(6)式から得た値を図7に点線で結んで示した。(7)式から得た理論上の最大尾叉長は，484.50㎜を示し，(4)式の値より妥当な値ともいえる。この結果は先に述べた Lee 氏現象，即ち高年魚の若年時における輪紋形成体長の小型化の結果を，そのまま評価した計算方法では理論上の最大体長を小さく推定して事実と一致しにくいことを示している。式(7)，(8)から1〜4才までの尾叉長と体重の関係を表3に示した。

Table 3. The sizes of red sea bream in fork length and body weight at the age of 1-4, calculated from the formula (7) and (8).

t (age in year)	1	2	3	4
Fork length (mm)	112.10	175.21	227.62	271.15
Body weight (g)	37.07	131.79	277.12	455.51

三尾（1962）は各地域で求められた計算尾叉長を比較するための指数として，Walford の定差方程式によって各結果の成長率を求め，地域別に次の式で示した。

伊　豆	$l_{t+1}=0.891\ l_t+90$	l_∞；825㎜
燧　灘	$l_{t+1}=0.892\ l_t+84$	l_∞；778㎜
佐賀関	$l_{t+1}=0.891\ l_t+56$	l_∞；514㎜
瀬戸内	$l_{t+1}=0.890\ l_t+73$	l_∞；662㎜
紀　伊	$l_{t+1}=0.887\ l_t+110$	l_∞；973㎜
若狭湾	$l_{t+1}=0.893\ l_t+76$	l_∞；710㎜
北九州	$l_{t+1}=0.873\ l_t+103$	l_∞；803㎜

広島中部海域は次式となる。

広島中部	$l_{t+1}=0.83\ l_t+82.11$	l_∞；485㎜

三尾の示した値と比べると，各式の傾斜の値が殆んど同じ値を示し成長率は変らない。初期成長を示す指数として用いられる Walford の定差式の定数項をみると，広島中央部は他地域に比べ低い値は示していない。しかし，理論上の最大尾叉長で比べると，佐賀関，北九州，若狭湾，紀伊水道より広島中部海域は低いことが分る。このことは，未成魚期内における年成長が他地域に比して小さいことを表わすものと推察される。

しかし，年成長の小さいことと投餌など管理飼育する場合のマダイ未成魚期の成長が極めて大きいことを比較して，魚類放流事業の中で生産効果と結びつけ将来を展望することは早計ではなかろうか。マダイの生息環境の諸条件や漁業条件等についても十分検討を加える必要があろう。

要　　　約

広島県中部海域産マダイ未成魚について，鱗の輪紋を計測し年令査定を行ない年成長について検討した。その結果は次のとおりである。

1）鱗長（R）と尾叉長（FL）の関係式は次式で示される。

$$FL = -33.93 + 48.54R$$

2）輪紋は年1回形成され，形成時期は4月から5月にかけて形成される。

3）尾叉長（FL）と体重（W）は次式で示される。

$$W = 5.60 \cdot 10^{-5} \cdot FL^{2.84}$$

4）未成魚期の成長過程から，成長および増重は次式で示される。

$$l_t = 484.50 \cdot \{1 - e^{-0.18(t+0.417)}\}$$

$$W_t = 2368.22\{1 - e^{-0.18(t+0.417)}\}^{2.84}$$

文　　　献

1）海老名謙一，1940：鯛の系統的研究（Ⅲ）日水誌，8(6)，295〜297。

2）相川広秋，1960：資源生物学，418pp・1金原出版ＫＫ。

3）三尾真一，1962：九州における沿岸魚類の資源生物学的研究Ⅳ，九大農学部学芸雑誌，17(4)，507〜520。

4）村上子郎・岡田啓介，1967：東シナ海・黄海産マダイ資源の研究Ⅲ，西海区水産研究所，業績第211号。

Appendix

Data records of scale measurment.

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
	May 24, 1973	298	610	7.35	3.13	4.88	6.10	7.21	0.126
		277	462	6.94	3.02	4.57	6.02	6.81	0.165
Tadanoumi		285	460	5.85	3.61	4.72	5.51		0.430
		255	323	5.80	3.49	4.63	5.67		0.125
		267	430	4.72	3.19	3.72	4.26		0.868
		242	320	5.70	2.99	4.69	5.55		0.174
		246	331	6.11	2.91	4.63	5.91		0.156
		244	308	5.22	2.58	3.99	5.07		0.139
		226	250	5.45	2.49	4.21	5.28		0.159
		243	312	5.17	2.51	3.96	5.00		0.163
		230	270	5.47	2.97	4.52	5.35		0.145
		220	244	5.32	2.38	4.13	5.18		0.133
		258	343	6.26	2.54	4.13	6.07		0.098
		233	277	5.91	3.11	4.84	5.81		0.103
		230	286	5.61	2.88	4.74	5.51		0.130
		244	306	5.98	2.96	4.65	5.86		0.099
		247	323	6.11	3.22	4.62	5.96		0.112
		219	242	5.58	2.73	4.30	5.44		0.123
		224	240	5.70	3.24	4.86	5.59		0.151
		228	254	5.26	2.44	3.89	5.15		0.087
		219	216	4.78	2.75	4.06	4.67		0.180
		215	207	5.18	2.53	4.01	5.05		0.125
		205	208	5.14	2.67	4.19	5.02		0.145
		219	244	5.40	2.99	4.21	5.27		0.123
		229	272	4.96	2.62	4.08	4.84		0.158
		224	245	5.03	2.29	3.75	4.92		0.094
		221	242	5.63	2.50	4.35	5.50		0.113
		216	222	5.53	3.17	4.41	5.41		0.120
		206	207	5.08	2.92	4.00	4.57		0.895
		211	205	4.77	2.47	3.98	4.66		0.162
		192	150	4.59	2.87	3.84	4.48		0.172
		215	230	4.99	2.46	3.75	4.88		0.097
		202	201	5.30	2.38	4.05	5.18		0.106
		188	200	4.73	3.04	4.61			0.076
		210	225	5.55	3.50	5.39			0.085

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		211	204	4.92	2.94	4.78			0.076
		198	163	4.63	3.33	4.46			0.150
		191	145	4.58	3.15	4.49			0.067
		187	152	4.55	2.95	4.45			0.067
		182	145	4.50	3.12	4.39			0.087
		185	146	4.16	2.66	4.05			0.079
		188	156	4.57	2.88	4.43			0.090
		187	163	4.83	2.80	4.65			0.097
		183	134	4.78	2.86	4.67			0.061
		173	138	4.16	2.75	4.05			0.085
		166	110	4.10	2.25	4.01			0.051
		180	132	4.40	3.11	4.28			0.103
		202	192	4.45	2.98	4.34			0.081
		176	129	3.91	2.24	3.81			0.064
		170	122	4.32	2.44	4.22			0.056
		173	136	4.13	2.40	3.99			0.088
		182	134	4.12	2.81	4.02			0.083
		182	140	4.46	2.43	4.35			0.057
		192	152	4.58	3.22	4.47			0.088
		175	120	4.18	2.69	4.08			0.072
		165	95	4.15	2.78	4.04			0.087
		176	107	4.25	2.73	3.74			0.505
		183	125	4.75	3.21	4.65			0.069
		188	150	4.77	3.34	4.62			0.117
		179	131	4.72	2.80	4.60			0.067
		184	147	4.71	2.93	4.60			0.066
		182	133	4.42	2.69	4.32			0.061
		175	120	4.48	2.78	4.34			0.090
		168	112	4.09	2.58	3.95			0.102
		170	110	4.60	3.03	4.46			0.098
		173	112	4.02	2.35	3.81			0.144
		158	105	4.20	2.95	4.05			0.136
		170	115	4.10	2.16	3.94			0.090
		159	104	4.04	2.75	3.91			0.112
		155	80	4.23	2.88	4.09			0.116
		158	80	4.28	2.78	4.15			0.095
		145	80	3.76	2.40	3.59			0.143
		147	73	3.99	2.42	3.82			0.121
		142	70	3.70	2.48	3.52			0.173
		155	82	4.06	2.73				0.487

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		152	81	3.78	2.51				0.506
		134	57	3.20	2.91				0.100
		133	62	3.68	3.37				0.092
		133	50	3.26	3.08				0.058
		140	60	3.59	3.48				0.032
		128	50	3.42	3.31				0.033
		131	51	3.40	3.30				0.030
		124	40	3.12	3.02				0.033
		125	45	3.25	3.16				0.028
		119	38	3.18	3.05				0.043
		114	35	3.18	3.07				0.036
		108	30	2.62	2.40				0.092
		107	27	2.52	2.40				0.050
		89	18	2.27	2.02				0.129
		123	44	3.06	2.82				0.085
		112	35	3.02	2.84				0.063
		107	31	2.78	2.54				0.094
	June 28, 1973								
		252	340	5.78	2.15	3.64	4.92	5.62	0.229
		255	330	6.00	2.60	3.82	4.67	5.79	0.188
		268	400	6.34	2.53	4.10	5.34	6.12	0.282
		246	320	5.90	3.02	4.23	4.96	5.57	0.541
		251	380	6.43	2.55	3.61	5.04	6.13	0.275
		245	340	5.75	2.20	3.52	4.62	5.52	0.256
		254	360	6.18	2.15	3.55	4.66	5.92	0.206
		241	290	5.90	2.62	4.10	5.10	5.71	0.311
		249	320	6.34	2.69	4.45	5.46	6.09	0.397
		233	300	5.59	2.40	4.05	5.30		0.232
		239	270	5.54	2.91	4.56	5.34		0.256
		235	340	5.82	3.00	4.17	5.50		0.241
		230	305	5.44	2.44	4.07	5.15		0.269
		212	250	5.19	2.87	4.00	4.98		0.214
		232	232	5.54	2.66	3.91	5.35		0.132
		226	275	5.41	2.58	4.37	5.22		0.224
		230	310	5.67	3.24	4.82	5.48		0.288
		233	280	5.50	3.08	4.48	5.28		0.275
		217	250	5.01	2.86	4.09	4.75		0.394
		203	210	5.18	3.06	4.22	4.83		0.574
		223	260	5.14	2.38	3.82	4.98		0.138
		214	220	5.13	2.55	3.74	4.90		0.198

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		218	230	5.28	2.81	4.14	5.10		0.188
		210	235	4.48	1.84	3.39	4.26		0.253
		222	240	4.98	2.34	3.60	4.76		0.190
		201	200	4.86	3.06	4.60			0.169
		194	170	4.48	2.90	4.29			0.137
		187	160	4.55	2.63	4.20			0.223
		184	150	4.30	2.71	4.13			0.120
		192	175	4.70	2.93	4.44			0.172
		180	150	4.41	3.03	4.16			0.221
		176	130	3.66	2.57	3.44			0.253
		171	125	4.05	2.87	3.85			0.204
		182	130	4.36	2.79	4.16			0.146
		164	105	3.89	3.31				0.175
		154	85	4.02	3.44				0.169
		152	80	3.85	3.39				0.136
		137	65	3.45	2.96				0.166
		124	45	3.33	2.82				0.181
		133	55	3.37	3.19				0.056
		138	65	3.47	3.04				0.141
		129	50	3.67	3.14				0.169
	July 26, 1973								
		301	552	7.02	2.77	4.40	5.56	6.58	0.431
		256	395	6.50	2.78	4.34	5.48	6.32	0.214
		262	436	6.03	2.57	3.84	5.40	5.92	0.212
		253	356	4.45	1.90	2.95	3.54	4.02	0.896
		238	325	5.30	2.68	3.82	4.57	5.18	0.197
		257	352	5.00	2.44	3.92	4.80		0.277
		239	300	5.06	2.28	3.52	4.74		0.262
		255	360	5.16	2.21	3.55	4.80		0.288
		247	344	5.22	2.32	3.80	4.94		0.246
		236	320	4.78	2.26	3.70	4.52		0.317
		224	265	5.00	2.36	3.76	4.77		0.228
		227	275	5.83	2.81	4.36	5.48		0.313
		215	245	4.72	2.45	3.88	4.55		0.254
		215	245	5.21	2.35	4.04	4.94		0.300
		216	195	4.17	2.21	3.32	4.01		0.232
		213	245	5.26	2.85	4.08	5.01		0.269
		230	260	5.21	2.59	3.95	4.87		0.370
		219	265	5.35	2.71	4.14	5.14		0.210
		260	382	6.12	2.95	4.38	5.67		0.349

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		236	315	5.42	2.57	4.06	5.21		0.183
		218	225	5.46	2.52	4.17	5.15		0.316
		217	232	5.67	2.56	4.18	5.46		0.164
		210	237	5.18	2.37	3.93	4.95		0.227
		242	305	5.79	2.32	3.83	5.44		0.217
		211	220	4.35	2.46	3.92			0.295
		206	218	5.32	3.18	4.75			0.363
		201	192	4.69	3.17	4.41			0.226
		222	240	5.42	3.33	5.06			0.208
		187	158	5.02	3.16	4.72			0.192
		188	177	4.32	2.24	3.75			0.337
		180	142	4.44	2.52	4.29			0.085
		164	113	3.91	2.31	3.61			0.231
		180	130	4.55	3.79				0.220
		174	120	4.45	3.82				0.165
		164	105	4.12	3.46				0.191
		160	100	3.99	3.31				0.205
		155	100	3.92	3.19				0.229
		156	94	3.88	3.15				0.232
		159	90	4.15	3.71				0.119
		148	75	3.57	2.77				0.289
		148	82	3.78	3.08				0.227
		144	75	3.80	3.10				0.226
		145	70	3.57	2.51				0.422
		159	90	3.86	3.13				0.230
		155	77	3.81	3.11				0.225
		158	95	4.15	3.40				0.221
		145	92	3.94	3.29				0.198
		150	83	3.26	2.58				0.264
		153	78	3.76	3.10				0.213
		157	100	4.11	3.26				0.261
		152	90	3.78	2.85				0.314
		153	85	3.88	3.12				0.244
		146	74	3.63	3.17				0.145
		163	105	3.96	3.18				0.245
		152	90	3.53	3.24				0.090
		156	103	4.01	3.31				0.211
		157	100	3.45	2.84				0.211
		150	76	4.00	3.45				0.159
		157	100	3.60	3.00				0.200

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$(R-r_n)$ / (r_n-r_{n-1})
	Aug. 25, 1973	154	87	3.64	2.98				0.221
		142	70	4.07	3.24				0.256
		307	630	7.42	2.40	3.83	5.40	6.82	0.423
		314	715	6.99	2.78	4.45	5.54	6.52	0.480
		286	525	6.03	2.85	4.18	5.43		0.480
		255	430	5.61	2.82	4.21	5.12		0.538
		275	520	6.28	3.10	4.92	5.82		0.432
		260	440	5.76	2.43	3.98	5.24		0.413
		255	390	5.57	2.24	3.71	4.84		0.646
		245	350	5.39	2.42	3.98	5.02		0.356
		246	345	5.79	3.03	4.27	5.37		0.382
		240	325	5.68	2.33	4.32	5.36		0.308
		235	310	5.13	2.32	3.75	4.73		0.408
		286	473	6.58	2.86	4.58	5.91		0.504
		285	507	6.48	2.89	4.75	5.99		0.395
		213	547	5.98	2.47	4.32	5.48		0.431
		241	330	5.84	2.84	4.43	5.41		0.439
		250	355	6.07	3.00	4.41	5.57		0.431
		235	307	5.45	2.55	3.95	5.03		0.389
		240	325	5.28	2.66	3.95	4.90		0.400
		246	345	5.56	2.59	4.43	5.25		0.378
		240	320	5.51	2.35	4.05	5.22		0.248
		226	275	5.14	2.26	4.23	4.94		0.282
		227	276	5.33	2.80	3.98	4.98		0.350
		219	275	5.32	2.67	4.23	4.98		0.453
		245	360	5.49	2.88	4.67			0.458
		207	230	5.10	2.64	4.48			0.337
		216	230	4.97	2.61	4.60			0.186
		218	215	5.14	2.94	4.60			0.325
		182	150	4.38	2.75	4.07			0.235
		195	195	4.77	2.87	4.38			0.528
		158	130	4.15	3.10				0.339
		165	100	4.17	3.38				0.234
		168	120	4.33	3.37				0.285
		168	105	4.24	3.13				0.355
		158	100	3.84	2.72				0.412
		155	95	3.94	2.77				0.422
		160	100	3.88	3.13				0.240
		153	97	3.84	3.25				0.182

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$(R-r_n)/(r_n-r_{n-1})$
		157	102	3.94	2.84				0.387
		146	95	3.59	2.65				0.355
		155	85	3.57	2.98				0.198
		147	78	3.77	2.85				0.677
		142	70	3.99	2.97				0.343
		147	78	3.54	2.89				0.225
		171	130	4.30	3.66				0.175
		175	135	4.41	3.53				0.278
		185	155	4.41	3.69				0.195
		174	120	4.52	3.37				0.341
		168	110	4.38	3.58				0.223
		157	105	4.14	3.12				0.327
	Sept. 26, 1973								
		285	525	5.33	2.15	3.32	4.09	4.74	0.908
		282	515	5.28	2.39	3.41	4.36	4.96	0.533
		265	455	6.05	2.43	3.89	5.36		0.469
		270	445	6.51	2.62	4.17	5.56		0.683
		245	365	6.10	2.84	4.09	5.37		0.570
		245	335	5.62	3.08	4.30	5.19		0.483
		245	335	5.86	2.63	4.11	5.18		0.636
		250	365	5.84	3.04	4.27	5.35		0.454
		216	250	5.06	2.26	3.67	4.59		0.511
		222	265	5.42	2.87	4.29	5.10		0.395
		224	255	5.04	2.46	3.96	4.71		0.440
		235	295	5.58	3.04	4.45	5.20		0.507
		215	240	5.27	2.57	4.08	4.81		0.630
		245	440	6.05	2.55	4.09	5.28		0.647
		238	315	5.13	2.59	4.03			0.764
		225	265	4.90	2.63	4.31			0.351
		213	255	5.02	2.86	4.54			0.286
		212	235	5.22	2.51	4.34			0.481
		222	260	4.81	2.96	4.14			0.568
		216	230	5.02	2.92	4.11			0.765
		215	240	5.19	3.34	4.40			0.745
		195	180	4.68	2.59	3.89			0.608
		196	192	4.92	3.07	4.19			0.652
		219	215	4.95	2.88	4.29			0.468
		208	235	5.12	2.88	4.48			0.400
		200	200	5.16	2.77	4.41			0.457
		192	170	4.72	2.49	3.94			0.538

Locality	Date of sampling	F.L. mm	B.W. g	R mm	r_1 mm	r_2 mm	r_3 mm	r_4 mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		197	190	4.26	2.11	3.52			0.525
		193	165	4.64	2.85				0.628
		188	162	4.45	3.02				0.474
		190	165	4.47	2.90				0.541
		190	150	4.27	2.78				0.536
		173	138	4.19	3.01				0.392
		192	165	4.67	3.23				0.446
		176	150	4.47	3.40				0.315
		181	140	4.42	3.04				0.454
		171	125	3.94	2.91				0.347
		180	135	4.52	3.13				0.444
		171	125	4.37	2.93				0.491
		170	120	4.51	3.34				0.350
		170	125	4.32	2.77				0.560
		170	115	4.19	2.87				0.460
		174	120	4.18	3.12				0.340
		167	115	4.24	2.86				0.545
		177	125	3.91	2.80				0.396
		162	110	4.31	3.02				0.427
		180	145	4.05	2.77				0.462
		171	120	4.33	2.59				0.672
		175	130	3.97	2.66				0.492
		166	115	4.23	2.72				0.555
		200	185	4.58	3.02				0.517
		182	145	4.77	3.11				0.534
		180	135	4.77	3.15				0.514
		176	125	4.68	3.02				0.550
		164	95	4.16	3.04				0.368
		161	100	4.42	2.66				0.662
		144	90	3.37	2.55				0.322
		172	120	3.85	3.05				0.262
		158	105	3.94	2.95				0.336
		177	130	4.29	3.11				0.379
		165	115	4.32	3.05				0.416
		183	150	4.73	3.20				0.478
		164	110	3.98	2.86				0.392
		170	110	3.59	2.77				0.296
		165	110	4.01	3.03				0.323
		182	150	3.94	2.53				0.557
		175	130	4.09	2.75				0.487

Locality	Date of sampling	F.L. mm	B.W. g	R mm	r_1 mm	r_2 mm	r_3 mm	r_4 mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		178	145	4.03	2.87				0.404
		173	120	4.07	3.01				0.352
		163	115	4.89	2.97				0.354
		162	105	4.00	2.99				0.338
		152	85	3.77	2.55				0.478
		165	110	4.02	2.64				0.523
		165	110	3.53	2.60				0.358
		165	105	3.99	3.06				0.304
		158	100	3.95	2.77				0.426
		171	130	4.52	3.31				0.366
		157	95	4.05	3.12				0.298
		157	95	4.08	2.71				0.506
		157	90	3.91	2.56				0.527
		152	95	3.57	2.09				0.708
		163	105	3.87	2.68				0.444
		160	95	4.05	3.06				0.324
		163	105	3.56	2.47				0.441
		153	95	3.95	2.81				0.406
		142	75	3.41	2.34				0.457
		152	85	4.02	2.66				0.511
	Oct. 30, 1973								
		281	500	6.56	2.66	3.79	4.99	5.87	0.784
		305	569	6.78	2.75	3.75	4.60	5.75	0.896
		300	628	7.69	2.78	4.23	5.28	6.75	0.639
		313	650	7.57	3.05	4.10	4.95	6.34	0.885
		313	700	7.52	3.35	5.00	6.17	6.97	0.668
		334	802	6.58	2.48	3.60	4.71	5.78	0.748
		260	432	6.39	2.92	4.30	5.30		1.090
		264	398	6.23	2.42	3.96	5.26		0.746
		270	455	6.13	2.81	4.31	5.50		0.529
		270	412	7.17	2.87	4.54	6.01		0.798
		285	560	7.29	3.26	4.82	6.30		0.669
		172	136	4.57	2.86				0.598
		172	126	4.62	3.15				0.467
		163	100	4.67	3.45				0.354
		168	114	4.29	2.69				0.595
		189	181	5.41	3.57				0.515
		179	166	4.57	2.90				0.576
		181	157	4.83	3.17				0.524
		171	147	4.47	2.97				0.505

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		190	157	4.71	3.05				0.544
		196	184	4.98	3.17				0.571
		194	196	5.36	3.60				0.489
		188	162	4.24	2.83				0.498
		179	144	4.43	3.04				0.457
		174	142	4.66	2.81				0.658
		175	126	4.37	2.72				0.607
		196	191	5.01	3.45				0.452
		195	168	5.30	3.32				0.596
		166	129	4.56	2.85				0.600
		177	156	4.40	3.20				0.375
		184	150	5.09	3.36				0.515
		187	178	5.12	3.48				0.471
	Nov. 28, 1973								
		193	175	4.37	2.90	3.81			0.615
		199	198	4.46	2.68	3.91			0.447
		204	193	5.18	2.82	4.59			0.333
		201	190	4.68	2.80	4.13			0.414
		204	200	4.58	2.78	4.07			0.395
		197	174	5.02	2.94	4.45			0.377
		180	137	4.78	2.77	4.23			0.377
		183	150	4.83	2.74	4.33			0.314
		151	95	3.71	2.88				0.288
		139	67	3.45	2.73				0.264
	Dec. 19, 1973								
		269	504	5.95	2.50	3.76	4.82		1.066
		245	315	5.11	2.44	3.73	4.59		0.605
		253	385	5.87	2.63	3.79	5.19		0.564
		260	447	6.58	3.07	4.85	6.01		0.491
		242	325	5.18	2.35	3.46	4.69		0.398
		233	300	5.75	3.08	4.47	5.45		0.306
		228	280	5.13	2.76	4.21			0.634
		223	297	4.98	2.54	4.03			0.638
		217	250	5.20	3.07	4.58			0.411
		220	240	4.79	2.49	4.29			0.278
		223	240	5.04	2.74	4.52			0.292
		215	227	5.22	2.99	4.86			0.193
		219	233	4.34	2.21	3.90			0.260
		197	166	5.32	2.79	4.86			0.222
		195	169	4.80	3.00	4.47			0.224

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		211	203	5.00	3.02				0.655
		211	206	4.79	2.95				0.623
		204	185	4.97	3.27				0.519
		207	208	4.96	3.26				0.521
		202	186	4.75	2.98				0.593
		208	215	4.93	3.04				0.621
		205	187	4.48	2.78				0.611
		195	195	4.77	3.13				0.523
		197	180	5.16	3.50				0.474
		191	165	3.94	2.74				0.437
		188	170	4.49	2.98				0.506
		193	164	4.61	2.89				0.595
		186	160	4.24	2.68				0.582
		197	174	4.47	2.76				0.619
		183	148	4.72	2.98				0.583
		185	150	4.56	3.11				0.466
		187	170	4.62	3.27				0.412
		185	142	4.63	2.99				0.548
		183	142	4.15	2.67				0.554
		190	148	4.46	2.93				0.522
		185	143	4.41	2.74				0.609
		174	148	4.19	2.54				0.649
		185	142	4.63	3.01				0.538
		172	126	4.38	3.01				0.455
		166	112	4.37	2.58				0.693
		167	113	3.78	2.47				0.530
		160	101	3.88	2.90				0.337
	Feb. 5, 1974								
		274	410	6.94	2.63	4.49	6.06		0.561
		253	370	5.64	3.10	4.18	4.98		0.825
		236	310	5.09	2.54	3.87	4.54		0.821
		244	370	5.76	2.80	4.21	5.16		0.632
		237	325	5.41	2.54	3.86	4.75		0.742
		227	280	5.68	2.81	4.56	5.34		0.436
		226	332	5.69	3.18	4.38	5.18		0.638
		221	170	4.90	2.91	3.86	4.53		0.552
		218	250	5.11	2.47	4.17			0.553
		195	210	4.90	3.00	4.29			0.473
		206	233	4.62	2.80	4.12			0.379
		203	184	4.97	2.96	4.28			0.523

Locality	Date of sampling	F.L.mm	B.W.g	Rmm	$r_1$mm	$r_2$mm	$r_3$mm	$r_4$mm	$\frac{(R-r_n)}{(r_n-r_{n-1})}$
		193	160	4.92	3.14	4.32			0.508
		197	163	4.49	2.68	3.97			0.403
		190	174	4.42	2.99				0.478
		188	173	4.35	3.17				0.372
		193	172	4.46	2.69				0.658
		187	195	4.04	2.43				0.663
		197	155	4.66	3.36				0.387
		181	168	4.20	2.86				0.469
		181	155	4.46	3.15				0.416
		175	140	4.00	2.67				0.498
		149	120	3.93	2.95				0.332
	Apr. 4, 1974								
		285	416	6.39	2.78	4.10	5.14	5.86	0.736
		276	414	6.46	2.79	4.20	5.36		0.948
		270	408	6.46	2.85	4.19	5.36		0.940
		240	270	5.79	3.22	4.73			0.702
		189	191	4.72	2.65	3.71			0.953
		218	235	5.31	3.45				0.539
		216	204	4.85	2.92				0.661
		198	161	5.17	3.46				0.494
		182	150	4.79	3.25				0.474
		184	163	4.89	3.36				0.455
		155	115	3.94	2.52				0.563

Bull. Nansei Reg. Fish. Res. Lab. (8) 101~111 (1975)

生物群集内における稚魚期および若魚期のマダイの摂餌生態—I.

他魚種との関係

今林　博道[*-1]・花岡　資[*-2]・高森　茂樹

Feeding Activities of Juvenile and Young Red Sea Bream, *Chrysophrys major* TEMMINCK et SCHLEGEL, in the Biotic Community-I.

Relation to the Other Species

Hiromichi IMABAYASHI[*-1], Tasuku HANAOKA[*-2] and Shigeki TAKAMORI

The feeding activities of juvenile red sea bream, *Chrysophrys major* TEMMINCK et SCHLEGEL, one of the important commercial species in the Seto Inland Sea, are needed to be made clear in the course of so called Farming Fishery which release many hundred thausands of juvenile seed fish into the natural nursery grounds.

Juvenile red sea bream bottoms to "Moba" - sea weed bank - in early summer after the stages of egg and drift larvae. Thus, they enter into the biotic community of "Moba" inhabited by many kinds of smaller fish.

The present study was planned to investigate the ecological relations between red sea bream and two other major fish species in the "Moba" community, red velvetfish, *Hypodytes rubripinnis* (TEMMINCK et SCHLEGEL), or network filefish, *Rudarius ercodes* JORDAN et FOWLER, which occur frequently together with in the catch, and are predominant in the bottom assemblages in the survey bank.

Here are reported the species compositions of catch and their stomach contents, and the results of study on the inter-specific competition for food, between red sea bream and other two major fish species. Their stomach contents composed of small benthic or phytal animals were observed to change along with the relative abundance of fishes concerned, and have led us to realize the tense competition for food among them.

However, formation of different schools by species and its dynamic segregation to each other tend to reduce the intensity of food competition, and it seems to reveal that dynamic segregations based on the relative abundance of these species as well as the abundance of prey animals act an important role in the competitive relations in the community of fishes on the survey bank.

1975年 8 月15日受理　南西海区水産研究所業績53号

*—1. 九州大学農学部 Faculty of Agriculture, Kyushu University

*—2. 日本大学農獣医学部 Faculty of Agricultur & Veterinary Medicine, Nihon University

沿岸水域に生息し水産的に重要な漁業資源である底魚の有効な再生産をはかるためには，まず自然環境下でのそれらの成育段階別生活様式，とりわけ生物群集内における摂餌生態を群集生態学的な立場から明らかにする必要がある。

その基礎的研究の一環として，瀬戸内海備後灘の三原水道細ノ州水域における生物群集内の稚魚期および若魚期のマダイを対象魚種として，その摂餌生態を調べた。当水域は夏季に両生活期のマダイの集群成育場として知られ，矢野ら[1)]はその分布や生長生態に関する知見について述べており，また花岡ら[2)3)4)]は群集生態学的立場から報告をしている。しかし，マダイを中心とした底魚群集と環境内餌生物群集との対応関係や，それに反映される餌生物をめぐる種間競合および種内競合などの魚種相互間関係の解明は十分でない。そこで第一報では，底魚群集内におけるマダイの侵入定着，成育，移動拡散の実態と，それに伴って起る餌生物をめぐる他魚種との種間競合，について解析結果を述べる。

本文に入るに先だって，この研究の推進にあたり懇切なご援助，ご助言を得た南西海区水産研究所内海資源部第二室長矢野実氏に厚くお礼を申しあげる。また研究成果の発表について機会を与えていただいた所長花村宣彦博士，ならびに取りまとめについて助言をいただいた内海資源部多々良薫博士に謝意を表する。

材 料 お よ び 方 法

細ノ州水域は三原水道のほぼ中央に位置しそのなかに丘状に盛り上った浅瀬で，その丘頂は最干潮時には露出する（Fig. 1)。水深5 m以浅 (st. A) は砂または砂泥底でその周辺はアマモ場 (Zostera region)

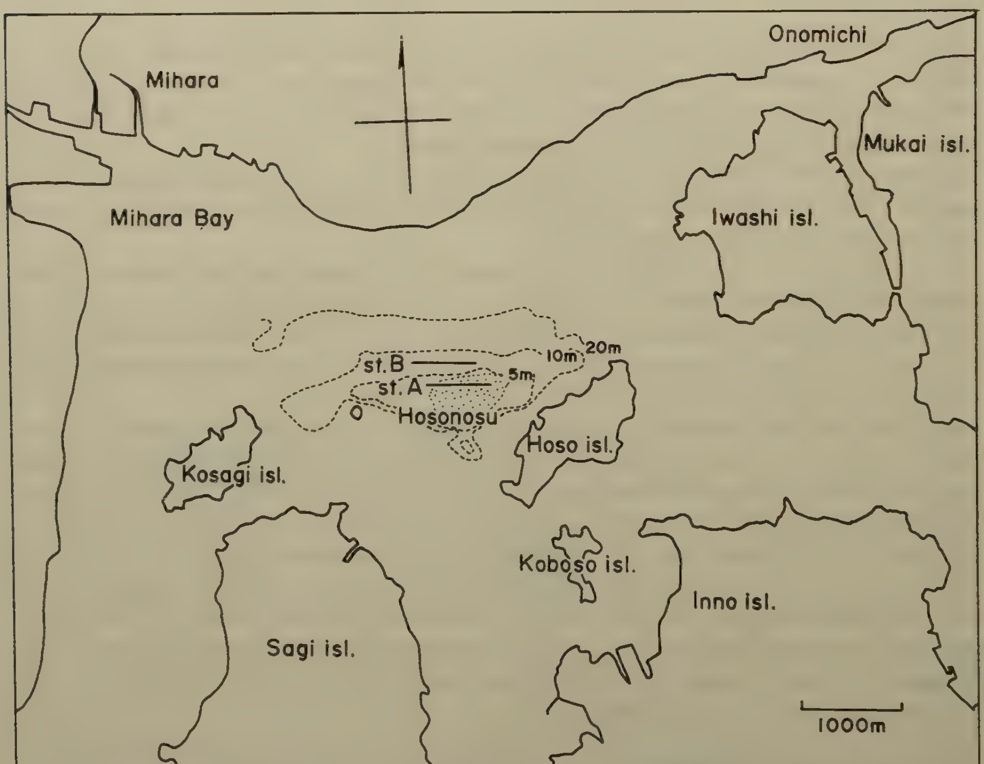


Fig. 1. Map of Hosonosu in the Bingo-Nada, Seto Inland Sea.
—— : The station where the net hauls (small type drag net) was made.

になっている。北側の水深5m以深（st. B）では，底質は砂または砂礫質でアマモの生育は観察されない。潮流は比較的速く（2.0kt），干満に伴い東西2方向に流れが交替する。なお，当水域は底曳網漁場の禁漁区に指定され，冬には海苔養殖場となる。

本水域内で物理的，植生的に環境が相異するst. Aとst. Bにおいて1972年6月26日から8月29日までの2か月間，昼間ほぼ週に1度，各々2～3回，小型の試験底曳網（網口3.2m，網丈3m，袋網丈0.7m）によりマダイをはじめとする魚種を採集した。その場合，できる限り1小群集を混合なしに捕えるため曳網時間は5分とし，曳網距離は毎回ほぼ一定（約400m）にした。採集した標本は船上で直ちに10％ホルマリンで固定した後，各種の数量組成を明らかにすると共に，それぞれの胃内容物について計量と生物種の同定を行なった。胃内容物の重量は感度1mgの天秤を使用し，マダイのように胃と腸の分化が明瞭な魚種では胃を，それがはっきりしない魚種では消化管の第1屈曲部から前部を切り取り内容物を沪紙上で水分をできるだけ取ってから計量した。

結　　　果

主要魚種の数量組成と出現頻度

細ノ州水域のst. Aとst. Bで全調査期間を通じて採集された主要魚種の数量組成と曳網ごとの出現頻度をTable 1に示した。st. Aではハオコゼ（*Hypodytes rubripinnis*），アミメハギ（*Rudarius ercodes*）

Table 1. Species composition of fish assemblages at Hosonosu.

	st. A			st. B		
Number of net hauls	22			21		
Number of species	25			15		
Total catch number	3,205			223		
Total catch weight (g)	24,455			2,158		
Fish ＼ Percentage	Number	Weight	Frequency of appearance*	Number	Weight	Frequency of appearance*
Chrysophrys major	14.2	8.3	81.8	54.8	21.0	81.0
Hypodytes rubripinnis	51.8	60.3	86.4	2.2	2.4	14.3
Rudarius ercodes	27.1	11.4	100.0	6.7	2.3	33.3
Sebastes inermis	2.5	5.1	54.5	0	0	0
Halichoeros poecilopterus	1.5	2.9	68.2	20.6	25.3	61.9
Ditrema temmincki	0.6	1.3	27.3	0	0	0
Triakis scyllia	0.4	4.3	27.3	0	0	0
Zebrias japonicus	0.3	1.0	27.0	0	0	0
Other spp.	1.3	4.5	—	14.9	37.9	—

* Number of appearance ×100/ number of net hauls

およびマダイの3種が卓越した存在である。すなわち，尾数および重量百分率はこの順に多くこれら3種をあわせるとそれぞれ93.1％，80.0％に達し，また1曳網ごとの出現頻度もこの3種に限り極めて高く81.8～100％の範囲にある。一方st. Bではマダイが数量組成および出現頻度ともに高く出現し，キュウセン（*Halichoeros poecilopterus*）がこれに次ぐ。このようにマダイは両採集場所の底魚群集の中で比較的優勢に生活していることがわかる。なお，st. Aは採集魚種数，全尾数，重量の点でst. Bの10倍以上に達していることから，マダイと共に多くの魚種が生息しより複雑な群集が形成されていると推察される。しかし

ここでは観察データーの信頼度およびマダイとの競合種の出現頻度を考慮して st. A の標本について解析をすすめた。

主要魚種の食性と出現傾向

主要魚種の胃内容物を餌生物種類別重量組成として表わすと捕食魚種の特徴が明らかになる（Fig. 2)。マダイ幼魚は生息環境の餌生物条件の違いによって胃内容物組成が変わるが，また成長に伴っても段階的に食性が変わる。

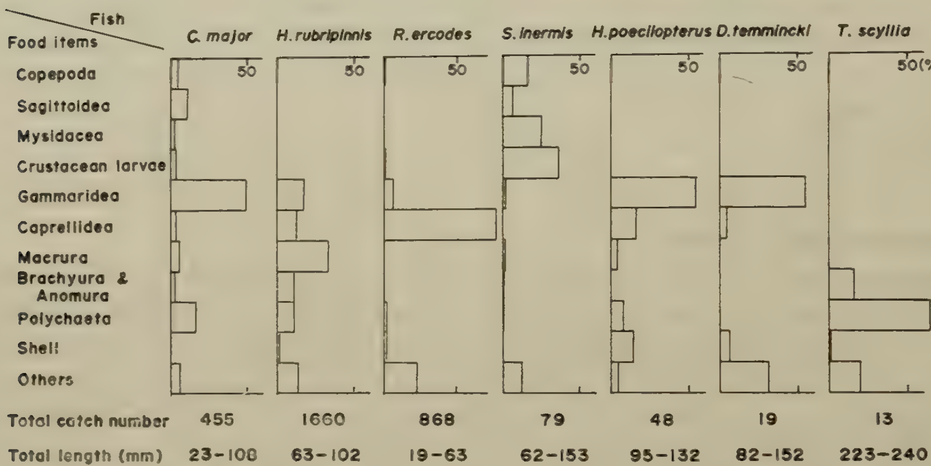


Fig. 2. Percentage weight composition of food items in several fishes.

ここでは小型甲殻類の Gammridea が胃内容物の約50%を占め，他の餌生物たとえば環形動物の Polychaeta は約20%，Macrura と Sagittoidea はそれぞれ約10%であり，ベントス食傾向を強くあらわしている。ハオコゼの胃内容物は Macrura が約35%で最も多く，次いで Gammaridea, Caprellidea, Brachyura & Anomura, Polychaeta および Isopoda がそれぞれ 10%前後を占め，これら７種類の餌生物でほぼ 100 %に達する典型的なベントス食である。アミメハギでは主としてアマモ葉上で生活する Caprellidea が約70%，同様に葉の表面に付着する腔腸動物 Hydrozoa が約15%であるのに対し Gammaridea は約５%と少なく，マダイの胃内容物組成とかなり異なっている。メバル（*Sebastes inermis*）は Crustacean larvae, Mysidacea, Copepoda などのプランクトン型餌生物を主体とする胃内容物組成を示す。マダイと同じスズキ目に属するキュウセンとウミタナゴ（*Ditrema temmincki*）の両種は，胃内容物の50〜60%が Gammaridea で占められマダイとその組成がよく似ている。サメ類の中でも沿岸性が強くまた出現した魚類でも最も大型のドチザメ（*Triakis scyllia*）は大型ベントス食を示し，約60%が Polychaeta である。いずれにしても，このように藻場で採集される魚種は胃内容物の種類から判断して，藻場に特徴的に多いベントスや葉上動物（付着動物）などを主な栄養源としている。

次に，これら主要魚種相互間の胃内容物組成の類似度を Morisita[5]）の類似度指数 C_λ によって求めた（Table 2)。この指数 C_λ の値は１に近いほど類似性が高く，０に近いほど低いことを意味する。マダイと他魚種の間のこの C_λ 値を３段階に大別して考えると，キュウセンとウミタナゴでは（0.91，0.88）最も高いが，アミメハギ，メバル，ドチザメでは（0.12，0.12，0.29）低く，ハオコゼは中程度（0.56）の類似性を示した。このうちキュウセンとウミタナゴは本来藻場に常住するものではなく，季節的にあるいは一時的に来遊して藻場を成育場として利用すると言われる。キュウセンは出現頻度が比較的高く（Table 1）マダイの出現した採集日には必ず混獲されているが，ウミタナゴはマダイの出現傾向とは逆である。藻場の定

Table 2. Values of similarity index C_λ* among each composition of food items in several fishes.

fish	*C. maior*	*H. rubripinnis*	*R. ercodes*	*S. inermis*	*H. poecilopterus*	*D. temmincki*	*T. sycllia*
C. major		0.56	0.12	0.12	0.91	0.88	0.29
H. rubripinnis			0.28	0.05	0.52	0.40	0.28
R. ercodes				0.01	0.33	0.15	0.01
S. inermis					0.03	0.04	0.04
H. poecilopterus						0.94	0.11
D. temmincki							0
T. scyllia							

* $C_\lambda = \frac{2\Sigma X_i Y_i}{(\lambda_X + \lambda_Y)\Sigma X_i \Sigma Y_i}$ $\lambda_X = \frac{\Sigma X_i^2 - \Sigma X_i}{\Sigma X_i (\Sigma X_i - 1)}$ $\lambda_Y = \frac{\Sigma Y_i^2 - \Sigma Y_i}{\Sigma Y_i (\Sigma Y_i - 1)}$

X_i, Y_i : Percentage weight composition of food items "i" found in the fish X and Y, respectively.

住種であるメバルも，Copepoda などのプランクトン型餌生物が豊富に存在していたと思われる採集日に限り多獲された場合を除くと，マダイの出現傾向と逆関係が認められる。しかしこれらの魚種はいずれも採集尾数が少なく，今後の調査が必要であろう。

考　　察

マダイとハオコゼあるいはアミメハギとの種間競合

混獲された魚種はマダイ幼魚を含む底魚群集の構成員であると考えて解析すると，ハオコゼとアミメハギは出現頻度およびマダイとの混獲率がともに高く，この2種とマダイが最も卓越していた。この両種は沿岸や内湾にある砂泥底のアマモ場で群泳生活をすることが知られているが，KIKUCHI[6] の天草のアマモ場における研究ならびに花岡ら[2,4] の調査からはこれら両種がマダイと同様に Gammaridea の捕食を主とする食性をもつとされている。したがって，ここではハオコゼとアミメハギに限定して若干の考察を加えた。

i ）生息量に影響された胃内容物組成の変化

マダイの胃内容物の重量組成を採集日別に求め，その体長範囲と1曳網当りの入網尾数を Figure 3 に示した。これによれば，マダイは成長に伴い胃内容物組成に明らかな変動がみられるが，7月7日から8月



Fig. 3. Change of percentage weight of food items in *C. major*.

11日までほぼ1か月間（全長，23～86㎜）の侵入定着期と成育期には常に小型甲殻類 Gammaridea を主食としており，8月18日以降に1曳網当りの入網尾数が急激に低下する移動拡散期（平均全長，83㎜）には Polychaeta などの大型ベントス食性に変わる。ただ，7月18日と25日にプランクトン型餌生物だけで胃内容物の大部分が占められているのは，その前後の様子からみてマダイ自身の生態的変化，すなわち食性が変わったためとは考え難く，何か次のような他動的影響が作用したためと考えられる。すなわち，(1) 環境内の Gammaridea 存在量の低下，またはプランクトン型餌生物の密度増大，さらにこれら2現象の相乗的な作用，(2) Gammaridea をめぐる臨時的に出現した他魚種との競合，などが指摘されるが，本水域では後者は考えにくい。

ハオコゼは終始一貫してベントス食性であるが，胃内容物組成や1曳網当りの入網尾数は採集日によりかなり変動している（Fig. 4)。

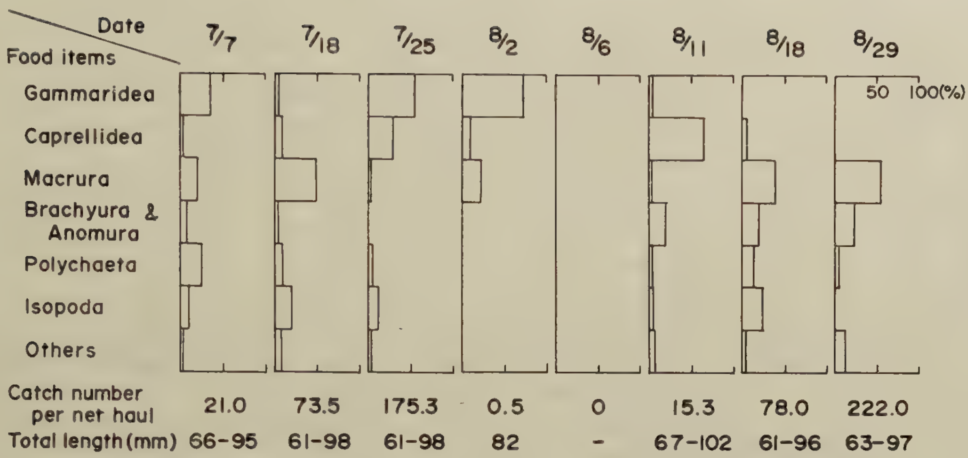


Fig. 4. Change of percentage weight of food items in *H. rubripinnis.*

アミメハギの胃内容物組成は採集日によらずほぼ一定しており前述したように葉上動物が優勢である。1曳網当りの入網尾数もハオコゼに比べて変動が小さく全期間を通じて出現している（Fig. 5)。

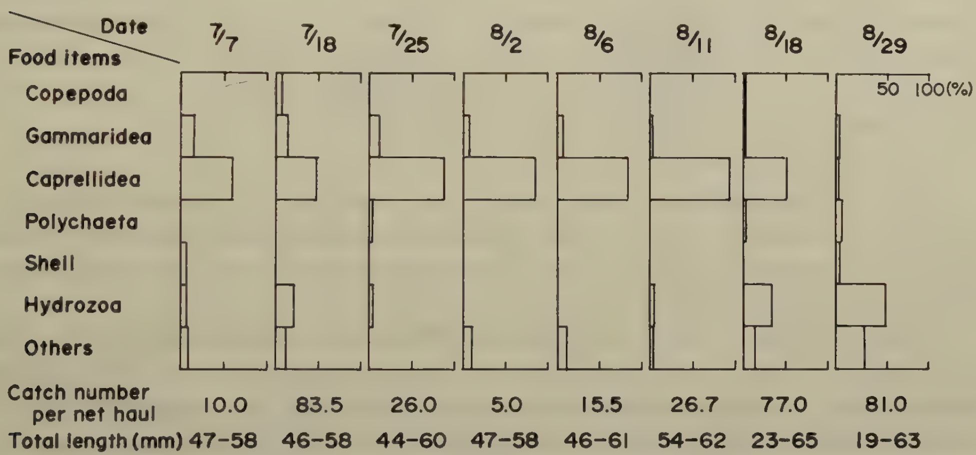


Fig. 5. Change of percetage weight of food items in *R. ercodes.*

以上のように3種の胃内容物組成と入網尾数の変化傾向とを別個に検討したが，次に胃内容物組成が3種の入網量に，すなわち密度依存的に変動したかどうかを検討する。そのため2魚種間について採集日別胃内容物組成の C_λ 値を求め，この C_λ 値と両種の合計入網量の変化関係を Figure 6 に示した。

マダイ対ハオコゼの C_λ 値はその範囲が広く0.12〜0.88にわたっており，両種の合計入網量に反比例して変わっている。このことは，入網量が生息量に比例するものとすれば，両種の生息量が多い日の C_λ 値は低く両種は互いに異なる餌生物を，逆に生息量の少ない場合の C_λ 値は高く同一種類の餌生物をより多く捕食することを示している。すなわち，両種は密度依存的に胃内容物組成を変えていると理解されるが，マダイの胃内容物の変化は少なく，ハオコゼの変化は大きいことから，マダイの優位性が認められる。

マダイ対アミメハギでは，その C_λ 値は0.02〜0.31と低くまたその変動幅もマダイ対ハオコゼの組合せに比べて小さいことから，両種は一般に生息量に比較的独立した胃内容物組成の差異をあらわすといえる。

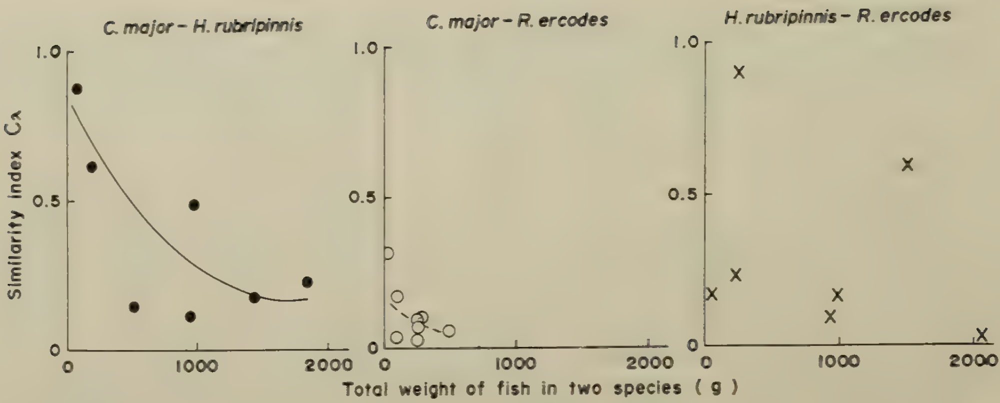


Fig. 6. Relation between Cλ values for food items in stomachs of two species caught by net haul and their total weight in it.

しかしその変動幅は小さいながらも生息量に対して反比例の傾向がうかがえる。

ハオコゼ対アミメハギでは，その Cλ 値は生息量の変化に伴ってばらつきが大きく一定の傾向を認めることはできない。

同様な現象は相対生息量が互いに違う２年度間（1969年，1972年）のマダイと他２魚種の Cλ 値変化の比較においても認められる（Fig. 7)。この事実はマダイに対するハオコゼとアミメハギの栄養生態学的地位が相対生体量の変化に対応して相互に入れ変わることを推定させる。なお1969年のマダイは1972年と同じく Gammaridea を主食としており，これらの群集内ではマダイを最優先種として，ハオコゼとアミメハギはその相対生体量によって群集内の地位が変化することを予想させる。

ii）生活空間における群関係

群行動をとり，あるいは群形成をしやすいと言われるこの生活期のマダイとハオコゼおよびアミメハギが，互いに重なった生活空間の中でその餌生物をめぐってどのような生息状態あるいは分布状態にあるかを次に解析した。曳網は全部で22回実施し，曳網ごとに求めた２魚種の相対出現割合の頻度組成を Figure 8 に示した。

マダイ対ハオコゼの場合（Fig. 8)，マダイの相対出現割合が40～60％と両種がほぼ同尾数で出現した曳網頻度は１回だけであるが，0～10％あるいは90～100％とどちらかの魚種が相対的に多く出現した曳網頻度はそれぞれ８回，４回であって全曳網数の半数以上にも達する。すなわち，曳網ごとの両種の相対割合はいずれか一方に偏りやすい傾向を示している。これは両種がその群行動あるいは群形成を比較的分離して行なう結果生じたものと考えられ，いわゆる動態的隔離の存在を推定させる。

マダイ対アミメハギの場合（Fig. 8)，この状況は幾分異なっている。マダイの相対出現割合が50～100％とマダイが多く出現する曳網頻度は６回だけである。全出現量がマダイの約２倍に相当するアミメハギは（Table 1）曳網ごとの組成を調べても数的に優勢であることがわかり，両種は群行動あるいは群形成を分離する度合が弱まりむしろ混生する傾向をあらわしている。

ハオコゼ対アミメハギの場合は両種の相対的出現割合には特徴的な偏りがなく，両種が群集内において極めて任意に混生することがうかがえる。先に求めた生息量および胃内容物組成の不定関係から考え合わせて，両種間には餌生物をめぐる直接的な相互作用はないと見做しえよう。これらの関係は Cλ 値の大小ともよく関連対応している。

以上を総括すると，本来互いに生活様式や生態的地位が比較的類似しているものと推察されるマダイとハオコゼあるいはアミメハギとの間には，餌生物をめぐって競合関係が成立していることが考えられる。1969年度ではハオコゼとアミメハギが量的にもマダイとの相互関係においても本年度とは全く逆の関係にあった

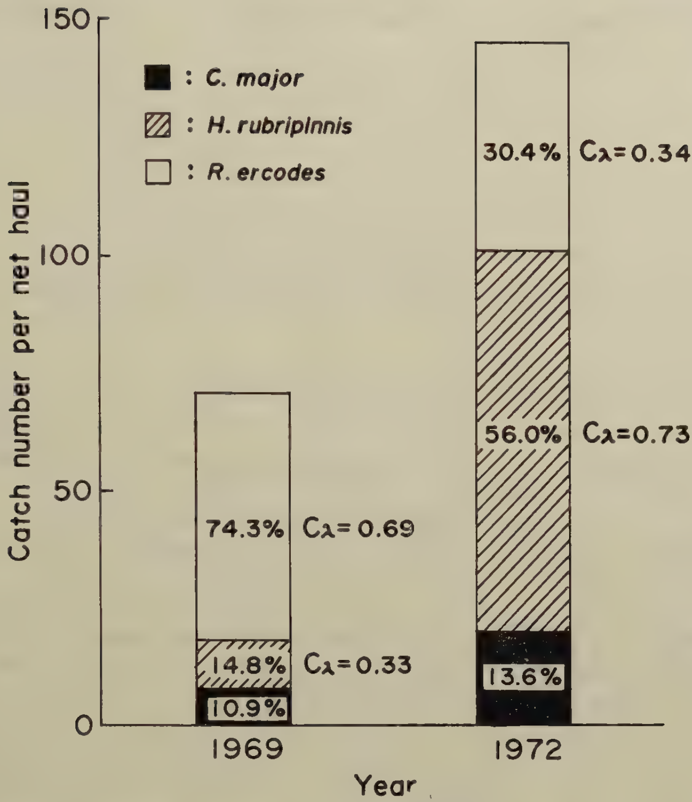


Fig. 7. Relation between C_λ* values for food items in stomachs of *C. major* and other species and various number composition of three species.

* Xi, Yi: Percentage composition of fish taking food items "i" found in the fish X and Y, respectively.

ことが報告されているが，本年度ではマダイ対ハオコゼの胃内容物組成が比較的類似し，かつ密度依存的に影響されているのがみられる。そしてその競合関係は利用する生活空間を群行動あるいは群形成の仕方で分離することにあらわれており，それによって種間の緊張を緩和していると思われる。これと対照的に胃内容物組成が異なり，その変化が両種の生息量にそれ程はっきりとした影響を受けないマダイ対アミメハギの競合関係は，同時に生活空間を利用して空間的な群の分離性の弱さを示しながら，指向する餌生物を分離することにより，両種間の緊張関係を緩和しているものとみられる。

マダイと他魚種との相互作用については以上の知見を得たが，沿岸水域の中でも魚類が豊富に生息しているアマモ場についての群集生態学的研究例は数多くの報告がある[6)7)8)9)10)11)12)]。このうち畑中ら[10)11)]は，生息場所が重なる魚種は相互に被食・捕食関係がなくても餌生物をめぐって相互に影響しあうものと考え，その胃内容物を調べることにより魚類群集の栄養生態学的地位を明らかにしている。一方，河川や湖に生活する淡水魚についても同様な報告[13)14)15)]がみられるが，その食性や行動などが生態的に特殊化したものは一般に少ないことが知られており，淡水魚について明らかにされた諸関係をそのまま海産魚に適用して考えることは危険であろう。しかし上述のように生息密度が高い底魚群集ではその生産性は，互いに接近して生活する魚種間の餌生物をめぐる競合関係を解明する必要性を推察させる。今後さらにこの側面からの

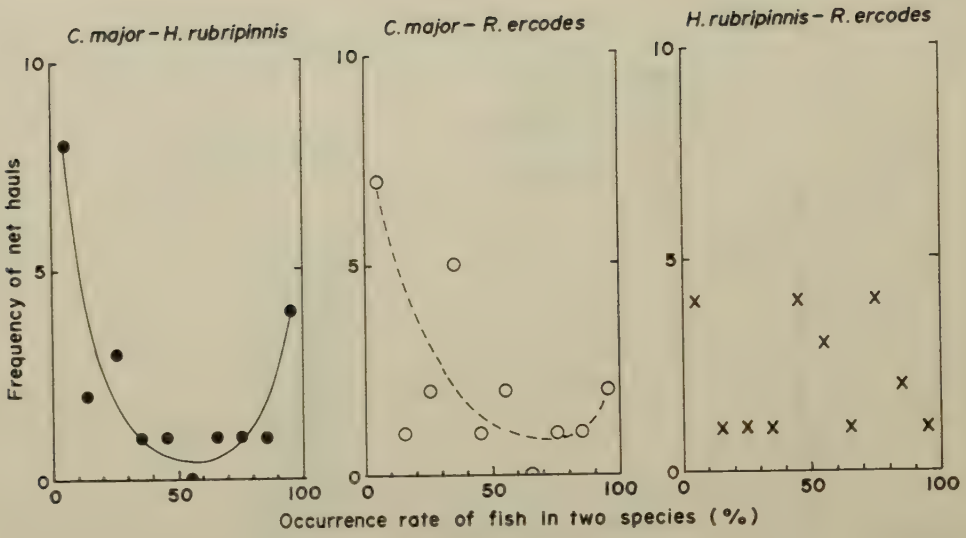


Fig. 8. Relation of frequency of net hauls occurred to percentage number composition of two species in it.

$$* \text{ Occurrence rate } = \frac{\text{Number of species X} \times 100}{\text{Total number of species X and species Y}}$$

X, Y: *C. major*, *H. rubripinnis* or *R. ercodes*.

検討が望まれる。

要　　約

沿岸水域内でも比較的生息密度の高いアマモ場周辺の底魚群集において，稚魚期および若魚期のマダイが一時的に定着する時期に，餌生物を捕食するに際して結びつきの深い他魚種との種間競合を解明することを目的として本研究を行なった。調査は夏季にマダイの集群成育場として知られている瀬戸内海備後灘細ノ州水域内の生物群集を選び，次の知見を得た。

(1) マダイと他主要魚種間との胃内容物組成の類似度指数 C_λ 値を求めると，キュウセンとウミタナゴでは0.91，0.88と最も高いが，アミメハギ，メバル，ドチザメではそれぞれ0.12，0.12，0.29と低く，ハオコゼは0.56と中程度の類似性を示した。

(2) このうち，底魚群集内において数量的に卓越し，出現頻度も高く，しかもマダイと曳網ごとに混獲される場合が多い魚種はハオコゼとアミメハギである。

(3) そこで，互いに生活様式が類似し密接な関係にあると考えられるマダイとハオコゼあるいはアミメハギ間にしぼって餌生物をめぐる競合を考察した。その結果，この競合は利用する生活空間内の群行動あるいは群形成の分離性と関連をもつことにより，魚種間の緊張を緩和していることが推察された。

文　　献

1) 矢野実，井上明，国行一正，高森茂樹，仁科重巳，1969：瀬戸内海備後灘におけるマダイ幼魚期の分布と生長．南西水研報，1，75—85.

2) 花岡資，井上善久，1970：マダイ稚魚を主体とする群集の組成の変動とその摂餌生態．内海性海域における生物群集の生産の動態に関する研究（JIBP-PM セクション），156—167.

3）花岡資，大石修宗，1972：マダイの食性について．浅海域における増養殖漁場の開発に関する総合研究，185—196.

4）花岡資，今林博道，1973：マダイ幼稚魚の食性．同誌，231—236.

5）Morisita, M., 1959 : Measuring of interspecific association and similarity between communities. *Mem. Fac. Sci. Kyushu Univ., Ser. E*, 3, 65—80.

6）Kikuchi, T., 1966 : An ecological study on animal communities of the *Zostera marina* belt in Tomioka Bay, Amakusa, Kyushu. *Publ. Amakusa Mar. Biol. Lab.*, 1(1), 1—106.

7）北森良之介，小林真一，1958：藻場の生態学的研究．(1)初夏相．内水研報，11，7—16.

8）北森良之介，永田樹三，小林真一，1959：藻場の生態学的研究．(2)季節的変化．同誌，12，187—199.

9）京都大学海洋生物研究グループ，1956：内湾における魚類の発育段階と生活場所．生物科学特集号，68—71.

10）畑中正吉，飯塚景記，1962：モ場の魚の群集生態学的研究—I．優占種をとりまく魚類の栄養生態学的地位，日水会誌，28(1)，5—16.

11）畑中正吉，飯塚景記，1962：モ場の魚の群集生態学的研究—II．モ場周辺の魚群集．同誌，28(2)，155—161.

12）布施慎一郎，1962：アマモ場における動物群集．生理生態，11，1—12.

13）Kawanabe, H., 1959 : Food competition among fishes in some river of Kyoto prefecture, Japan. *Mem. Coll. Sci. Univ. Kyoto, Ser B*, 26(3), 253—268.

14）Miura, T., 1959 : Some ecological studies on fish populations in Lake Sagami, an impoudment, in Kanagawa prefeture, Japan. *Bull. Freshwater Fish. Res.*, 9(1), 23—39.

15）Johannes, R. E. and P. A. Larkin, 1961 : Competition for food between redside shiners (*Richardsonius balteatus*) and rainbow trout (*Salmo gairdneri*) in two British Columbia Lakes. *J. Fish. Res. Bd. Canada*. 18(2), 203—220.

Bull. Nansei Reg. Fish. Res. Lab. (8) 113~124 (1975)

養殖アマゴ *Oncorhynchus rhodurus f. macrostomus* (GÜNTER) の白内障—II.

眼球の病理組織所見

松里寿彦・金沢庸一*

Studies on the Cataract of the Cultured Amago, *Oncorhynchus rhodurus f. macrostomus* (GÜNTER)-II.

Some Observations on the Histopathological Changes in Cataractous Lens and Other Organs of the Eye

Toshihiko MATSUSATO and Yoichi KANAZAWA

The occurrence of the cataract of fishes which caused by parasites and other factors in Japan have been very rare, and a few papers were reported on this aspect.[6)12)]

However, at the present time, there are many cases of cataract among the fry and juveniles of cultured amago, *Oncorhynchus rhodurus f. macrostomus* (GÜNTER) in almost amago-culturing farms in Japan. And, this disease seems to increase year by year.

In the previous paper,[5)] the authors described the occurrences of the cataract in cultured amago, and the results of the investigation about the distribution, the ratio of appearance, the environmental factors of culture ponds, and the differances of culture methods, from 1972 to 1974 in Japan.

In this study, two groups of samples collected from different regions in Japan have been examined histopathologically.

Results obtained are as follows:

1. Many types of prliferation of epithelial cells in the lens, e.g., invading cell-mass, migration cell-mass, duplicating epithelium, etc. are observed.
2. The edematous and liquefacious symptoms in the fiber-layers of the lens are obserbed.
3. SALMANN and et al.[13)]. have presented a excellent report that was described about the histological changes of the cataract of rainbow trout maintained on a thioacetamide diet for prolonged periods of time. Some discussions between our results and those of theirs are described.

1975年8月15日受理　南西海区水産研究所業績第54号

* ニツプン飼料株式会社技術部研究所, Res. Lab., Nippun Siryo Kaisha, Ltd.

最近，各地のアマゴ養殖場において，水晶体の混濁を主症状とする，いわゆる白内障病魚が散見される。白内障は，水晶体の病変を主徴とする疾病ではあるが，水晶体以外の眼球組織の異常を伴う場合も多く，本症を把握するには，眼球全体の病理組織像の検討が必要であろう。

魚類の白内障については養殖アマゴに限らず，他の魚種にも広く認められており，それらに関する報告も多い。[1)2)3)4)] しかし，それらの報告の多くは，水晶体および眼球組織の症状に関する記載が少なく，症状の確認も単に，肉眼的観察にとどまっている場合が多い。

著者らは，前報[5)]において，岐阜県を中心とする数県下，数十か所のアマゴ養殖場を対象に，養殖アマゴの白内障の発生状況などについて報告したが，その後，さらに，広島，徳島両県下養魚場で本症病魚標本を得ることができたので，前報で報告した各標本と併せ，主として病理組織学的検討を行ない，本症病魚の眼球各組織の病変に関して若干の知見を得たのでここに報告する。

報告に先だち，貴重な資料をご提供下さったニップン飼料株式会社，上松和夫氏および岐阜，徳島両県水産試験場関係各位に厚くお礼申し上げます。さらに，貴重な知見や文献をいただいた東京大学羽生功助教授，淡水区水産研究所横手元義技官に感謝いたします。また，本報告をまとめるにあたり，ご指導賜った保科利一博士，東京大学江草周三教授に深謝いたします。

材 料 お よ び 方 法

病理組織学的検討を行った標本は，採取場所，採取日時，固定法などが多様であるが，その主なものは，次の４群に分けられる。

標本１群：前報[5)]で報告した，1973年３月，岐阜県を中心に数県下で行った第１回調査の際，得られたもので約20尾の病魚標本（全長３～５㎝，体重0.3～2.0ｇ)。標本は，麻酔し，肉眼的観察後，直ちに Bouin 氏液で固定し，保存したものである。

標本２群：前報[5)]で報告した第２回目調査の際，得られたもので，1973年11月～1974年５月，岐阜県下養魚場で採取された病魚約30尾（全長３～９㎝，体重0.3～15.0ｇ)。比較的大きな個体は，観察，測定後，全身を３部に横断し，Bouin 氏液で固定し保存した。

標本３群：1974年３月，広島県の１養魚場で得た病魚約30尾（全長４～６㎝，体重0.3～1.5ｇ)。病魚は麻酔し，観察，測定後，全身を３～５部に横断し，Bouin 氏液で固定したほか，一部の個体については，眼球を摘出し，20％中性ホルマリン水溶液，Helly 氏液，Carnoy 氏液で固定した。その他，水晶体のみを摘出し，油浸用オイル（カーガイルオイル，日本光学製）で封入し，そのまま鏡検した。

標本３群の採取池における発病状況は次のとおりである。

採卵は1973年10月30日。採卵親魚は同年４～６月，９～10月，いわゆる「かび病」に罹病した。「かび病」発生当時，池口より，マラカイトグリーン液を摘下するなどの処置をし，生残魚を産卵親魚に用いた。

12月中旬に餌付け。この時点では眼球に異常は認められなかった。

３月７日，白内障病魚確認。３～４万尾中１日当り，50～80尾斃死。

３月15～18日，総合ビタミン剤（２％余飼料に添加)，フラン剤投与。

３月18日，白内障病魚採取および調査。調査時点では，放養尾数の約半数が肉眼的にも明らかに白内障症状を呈していた。

当池の飼育水温は約６℃。使用飼料はＮ社製ニジマス稚魚用クランブルのみであった。

標本４群：1974年４月，徳島県下養魚場で採取された病魚５尾の Bouin 氏液固定試料。

病魚は全身を２部に横断され，固定された状態で送付されたものである。

得られた標本は，必要に応じ両眼を含む横断片とし，Bouin 氏液で再固定した後，常法どおり，脱水，パラフィン包埋し，水晶体中央を含むよう注意し，５～８ μ の切片とした。

染色は，全標本とも，Mayer 氏ヘマトキシリン— Romeis 氏エオシン二重染色を行ったほか，一部の標

本については，MALLORY 氏 AZAN，PAS 染色などを行った。

結　　　　　果

検討した標本は孵化直後，餌付け前後のものから，餌付後百数十日経過したものまでを含み多様ではあるが，症状については共通な場合が多く，飼育日数などによる差違は明らかではないので，全標本について検討した結果を一括して述べる。

1.　白内障病魚の肉眼的所見

前報[5]でも一部報告したが，病魚の肉眼的所見は次のとおりである。

体色：病魚の体色は一般に褪色する場合が多く，青灰色ないしは灰白色を呈する。しかし，孵化直後～餌付け前の稚仔魚では体色の変化は明瞭ではない。

体型：体長，体重などには，正常魚とのあいだに差違は認められない場合が多い[6]。しかし，標本3群を得た発症例では，病魚は一般に摂餌不良となり，肥満度も明らかに低下したが，これら異常が本症に起因するものか否かは明らかでない。

鰓：異常は認められない。

各鰭：異常は認められない。

内臓各器管：剖検では，顕著な異常は認められない。

眼球：眼球突出，前房内出血などは認められない。極く一部の病魚に角膜の軽度の混濁が認められた。

水晶体の混濁は，肉眼的には次のように分類し得る。

(イ)　全体が強く白濁し不透明。

(ロ)　全体が軽度に白濁し，透明度も比較的高い。

(ハ)　水晶体内に層状の白濁層がみられ，全体としては不透明。

(ニ)　最外層のみ淡く白濁し，全体的には透明度は高い。

(ホ)　水晶体核のみ白濁する。

(ヘ)　外極（前極ともいい，水晶体の角膜側を指す）付近に点状もしくは斑状の強い白濁部が認められる。

白濁の程度および症状などは，両眼とも同じ場合が多いが，病魚の約10％余のもので，左右水晶体の症状が異なり，極端な例では，片眼水晶体は著しい白濁を呈するにもかかわらず，他側水晶体には，肉眼的には白濁が認められない場合もある。水晶体の肉眼的症状が，魚の成育段階別，飼育条件別で著しく異なることはなく，それぞれの成育段階においても，また，個々の発症池においても，前述した種々の症状がみられるが，全体としては，(ロ)および(ヘ)の症状を呈する病魚が比較的多いようである。

前報[5]でも述べたように，いずれの調査した飼育池においても，0.1～3.0％余の眼球奇形魚が認められる。奇形の主なものは，眼球欠損，角膜，水晶体欠損，変形などであるが，水晶体の著しい白濁を伴う，いわゆる奇形性の白内障も認められる。これら奇形性白内障魚の水晶体は，全体にほぼ均一に強く白濁し，水晶体も全般に小さい。また，これら水晶体の異常と同時に，虹彩，網膜の異常を伴う場合が多い。

2.　眼球各組織の病理組織所見

眼球各組織の染色標本の鏡検結果は次のとおりである。

角膜：アマゴの角膜は，外側から一層の偏平上皮細胞層，数層の上皮細胞層，AZAN 染色に青染し，PAS染色に赤染する境界膜，線維性結合織からなる固有層および角膜中央部では不明瞭ではあるが，一層の内皮層で構成されている。今回検討したアマゴ白内障病魚の角膜には，角膜上皮の肥厚，色素沈着などの異常は認められないが，一部の標本で，角膜固有層の水腫が認められた(Fig. 1)。

虹彩，水晶体筋（retractor lentis），水晶体支持靭帯（suspensory ligament）：明瞭な毛様体構造を欠く魚類では，虹彩基部に比較的粗な線維性の網状構造があり，虹彩支質には血管が分布している。上方の虹彩には水晶体支持靭帯が付随し，また，虹彩下方には特異な水晶体筋がある[7]。白内障魚のこれら虹彩周辺

部組織の異常としては，虹彩支質血管内に血液の貯溜が著しく少ないこと，および上方虹彩にしばしば銀膜とのはく離が生じていることが認められる（Fig. 2)。

眼房部，硝子体：重篤な病魚の前房部には，PAS 染色に赤染する微細な短線維状物および円形の遊離細胞が認められる場合がある。この短線維状物は，また，硝子体にもしばしば認められる。さらに，硝子体は網膜より，はく離し，萎縮の傾向が認められる個体である（Fig. 3, 4)。

網膜：奇形例を除き顕著な異常は認められない。

鎌状突起，その他血管，神経系：細毛血管および神経系については充分な検討を行わなかった。

水晶体：アマゴの水晶体は，最外部に，Azan 染色で青染する一層の透明な水晶体被膜があり，その被膜下には，神経乳頭側，いわゆる内極または後極と呼ばれる部分を除き，分裂，増生可能な単層の水晶体上皮細胞層がある。水晶体上皮は角膜側，いわゆる外極側では比較的偏平で，赤道部よりやや外極寄りの部分の細胞が最も大きく，細胞径 8 × 5 μ余，核径 4 × 3 μ余である。細胞は核質に富み，細胞質内にヘマトキシリン好性の顆粒がみられる。内極周辺では，水晶体上皮細胞は，線維化のため，細胞型，核などに著しい変化がみられる[8]。

水晶体線維層は，皮質と核に区分されるが，線維の形態などは，上皮が線維化する内極周辺と他の部位とでは差違があり，外極を中心とする大部分の水晶体皮質は，一様な細胞内物質に富む定型の細胞からなり，内極側は有核の長大な細胞からなっている[8]。

水晶体の病変は，これら三つの部分，すなわち，被膜，上皮，線維層（内極周辺皮質，その他皮質，核）の複合した異常とみなすことができるが，被膜はその構造上，単独で形態異常を呈することは少なく，多くの場合，上皮，線維層の異常に伴って異常を示す。

肉眼的所見の項で述べた，透明度の高い水晶体全体の軽度の白濁(ロ)，および層状の白濁層のみられる(ハ)など症状を呈する水晶体には，皮質線維層線維に膨潤が認められる場合が多い。それら膨潤した線維は，しばしば同心円状に層をなして認められる（Fig. 5–A, B)。このような例では，水晶体被膜および上皮には顕著な異常が認められない場合が多い。これら水晶体線維層にのみ異常の認められる白内障の出現率は高い。

肉眼的観察で，水晶体全体が均一に白濁している場合は，水晶体線維層の融解が認められることが多い。水晶体線維層の融解は，線維および上皮直下に空胞が形成される場合が多く，これらは主として赤道部より外極側で起こり，除々に水晶体全域の膨潤，融解に移行するものと思われる（Fig. 6, 7, 8)。著しく膨潤した線維層の網状構造内にはエオシン好性の顆粒が充満し，さらに変性が進むと，繊維層の構造は失れれ，一様な液状にまで至る（Fig. 9, 10)。 線維層の融解に伴い， 上皮の変性， 壊死などが認められる。また，線維層の全融解に至る過程で，水晶体核移動（Fig. 7)，水晶体皮質内極側の不規則な有核細胞の分布（Fig. 11）などが認められる。これら水晶体線維層の病変と，後述する水晶体上皮の病変との関連については充分検討し得なかったが，形態的には，線維層の異常が先行する場合が多く観察される。

アマゴ白内障魚における水晶体上皮の病変は多彩であり，複雑な症状を呈する。水晶体上皮の最も軽度の病変としては，細胞の不整，核の変形などであるが，これらは肉眼的には異常は認められない場合が多い（Fig. 12)。

肉眼的には，水晶体最外層の淡い白濁が認められる(ニ)の場合には，水晶体上皮の多層化が認められる場合が多い。上皮の多層化は，主として赤道部周辺より外極側で始まり，多層化の過程において細胞はむしろ大型となり，核の変形，大型化を伴う場合が多い（Fig. 13, 14)。水晶体上皮の多層化は， 水晶体全体を数層の細胞層で覆う場合（Fig. 15)，局部的に増加し，くさび状の細胞塊を形成する場合（Fig. 16)，さらに，増生した細胞塊が被膜より離れ，いわゆる遊離細胞塊を形成する場合などがある（Fig. 17)。水晶体外極周辺での上皮細胞の多層化，もしくは細胞塊形成は，肉眼的には，白濁点，白濁斑として認められる（Fig. 7, 18)。 また，餌付け前後の稚魚では，Fig. 19 に示すような， 水晶体全域の上皮の多層化がみられることがあり，このような例では，肉眼的には，水晶体全体が一様に不透明となる（Fig. 19)。

水晶体上皮に由来する細胞塊では，多様な細胞の変性がみられる。最も多くみられるものは，比較的大型

の不定形細胞で，核は円形ないしは長卵形である。細胞塊の深部，線維部深部に位置する細胞は，核の染色性が低下し，類壊死に至る（Fig. 20）。また，上皮の多層化，細胞塊形成のみられる多くの標本において，核の著しい変形，巨大化を伴う一連の変性細胞の出現が認められる。これらの細胞の細胞膜は不明瞭となり，細胞自体も著しく巨大化する（細胞径約 20×15 μ，核径約 14×8 μ）（Fig. 21, 22, 23）。これら異常細胞を含む細胞塊では核の分裂像もみられる（Fig. 24）。これら巨大細胞は，多数の仁を有する巨大変形核細胞（Fig. 25, 26），複雑な変形核を持つ細胞（Fig. 27）などを形成するに至るものと思われる。その他，多重の模様構造を持つ細胞，滴様の細胞内容物を持つ細胞などが認められる（Fig. 28）。

内極周辺の上皮細胞は，線維層への移行過程にあるため，膨潤した巨大な細胞を形成するほか，内極および内極周辺線維移行部にしばしば，いわゆる上皮真珠（epithelial pearl）を形成する（Fig. 29, 30, 31, 32）。

考　　察

魚類の白内障は，吸虫寄生による障害例として古くから知られており[3]，その後，マス類の人工孵化，飼育が盛んとなるにつれ，栄養性と思われる白内障が報告されている[1)2)9)10)11]。我が国においては，白内障の報告は少なく，その主なものとしては，田代ら，[6] 佐藤ら[12]のアマゴ，ニジマスでの報告があるにすぎない。しかし，これらの報告では，白内障の症状についての詳細な検討は行われておらず，病理組織所見を欠いている。一方，Sallmann ら[13]はニジマス稚魚を用いて，マス類の肝癌発生物質とされている Thioacetamide を長期間，多量に経口的に投与し，発現した水晶体上皮の増生を伴う白内障について，病理組織学的検討を行った。それによると，水晶体の肉眼的な病変として外極（anterior pole）周辺に灰色栓様物の出現を認め，また，組織病変として水晶体上皮の多層化，細胞塊形成，線維層内の遊離細胞塊形成，上皮真珠形成，線維層の空胞化，被膜の二次的形成などを認めている。その他，薬剤投与区の魚は一般に成長が悪く，肝臓に中心性壊死巣，肝腫様結節，胆管増生などが認められたとしている。これら Sallmann らの報告と，今回検討した養殖アマゴの白内障の水晶体の病変とを比較すると，多くの症状が一致する。すなわち，水晶体上皮の多層化，細胞塊形成，線維層の膨潤，融解，それらに伴う内極（posterior pole）周辺の一連の病変および多様な異常細胞の出現などは，両者に共通の症状といえる。しかし，Sallmann ら[13]は巨大な多形核細胞は観察しておらず，また，アマゴの場合，水晶体被膜の二次的形成は認められないなどの相違点もみられる。Sallmann らの使用した Thioacetamide が，今回検討したアマゴ白内障の原因物質として関与しているかどうかについては次の二つの点から否定し得るものと考える。一つは，Sallmann らは，同剤を多量に長期間投与し，12か月後に出現した白内障を検討しているが，アマゴの場合は，最も成育段階の進んだものでも，餌付け後約3か月のものであるにもかかわらず，症状は多様で，Sallmann らの記載したものより重篤な例が多く含まれている。二つには，前報で述べたように，異なる多くの配合飼料メーカーの飼料を使用していても同様な白内障の発現をみており，同時に，これら配合飼料中に多量の Thioacetamide の混入は考えられない。しかし，原因は異なると考えられるにもかかわらず，症状が類似するのは，水晶体という特異な組織においては，病変が進んだ場合は，病現像が似てくるものと考えられる[14)15]。このことは，Rafferty[16]の実験結果と比較しても同様であり興味深い。

Yokote[17]はコイの糖尿病である「せこけ病」の一連の研究において，網膜細毛血管の異常を報告しているが，さらに，肉眼的観察ではあるが，水晶体の白濁もあるとしており[18]，魚類の白内障の原因の一つに，糖代謝異常も含まれ得ることを示唆している。今回検討した標本においても，虹彩周辺の血行の障害および硝子体の変性など眼球組織内循環系の障害を疑わせる病変も認められており，今回検討し得なかった微細血管と併せ，今後さらに検討する必要があろう。

最近，岩田[18]は，遺伝性白内障マウスを材料に，水晶体白濁機構に関して，主として生化学的立場から総述を試みている。彼は，水晶体白濁の過程を引金反応期，代謝異常期，たんぱく反応期，混濁進行期，白濁期の5段階に分類し，各期の特異的反応を述べているが，光顕レベルでとらえ得るのは，このうち混濁進行

期以降であり，白内障の初徴である引金反応期はとらえ難いものと思われる。また，岩田は，「引金」は水晶体自体が内在的に持つ場合と，ナフタリン，ガラクトースなどで代表される薬物などの外因的な場合もあるとしている。今回検討した養殖アマゴの白内障の場合，形態異常を伴う奇形以外で最も初期に，肉眼的に白内障が確認されたのは，餌付け前稚仔魚で孵化後約20日後のものであり，この例では，水晶体上皮の増生，線維層の融解の状態などからみて，岩田のいう引金反応期は，遅くとも孵化前後まで逆のぼらざるを得ないものと思われる。

一方，極く最近，人為的に種苗生産されたマダイ稚魚（体長8～10cm）に，角膜および水晶体の混濁を主症状とする白内障が発生しており，また，養殖コイ（体長12～15cm）にも白内障魚が散見される。これらの白内障の詳細については別の機会にゆずるが，今回検討した養殖アマゴを含めて，これら白内障魚に共通していえることは，それぞれ数代にわたり人為的に飼育され，種苗も人工生産されていること，また，主として配合餌料で飼育されていることである。

今後は，これら他魚種の白内障の実態を明らかにし比較検討するとともに，疑しき要因についてさらに詳細な実験的検討を行う必要がある。また，温血動物の白内障で明らかにされている無機塩類代謝異常，水晶体上皮細胞の膜透過性の異常の有無および，それらの機構などについても検討を進める必要があると考える。

摘　　要

最近，我が国のアマゴ養魚場に広く発生している養殖アマゴの白内障について，病魚の眼球組織の病理組織学的検討を行ない，その症状の一端を明らかにするとともに，既往の報告との比較検討を行ない以下の知見を得た。

1）養殖アマゴの白内障病魚の眼球組織では，虹彩支質血管の血流阻害，硝子体の変性，水晶体上皮の増生と，それに伴う多彩な変性細胞の出現，水晶体線維層の膨潤および激しい融解変性，水晶体被膜の変形などが認められた。また，初期症状として線維層の層状の膨潤を認めた。

2）養殖アマゴ白内障にみられる病変の多くは，Sallmann ら[13]がニジマスで Thioacetamide 投与により実験的に発現させた白内障のそれに類似しているが，巨大変形核細胞，被膜過形成などに相違点が認められた。

3）養殖アマゴ白内障の原因機構解明のためには，他魚種における白内障との比較，初期病徴の把握，無機塩類のバランス等生化学的面からの検討などの必要性を指摘した。

文　　献

1) Hess, W.N., 1937 : Production of nutritional cataract in trout. Proc. Soc. Exp. Biol. Med., 37, 306–309.

2) Allison, L.N., 1960 : Cataract in hatchery lake trout. Prog. Fish-Cult., 22, 34–38.

3) Dogiel, V.A., 1961 : Parasitic diseases of fishes in natural water. Parasitology of fishes, Oliver and Boy., Edinburgh and London., 302–307.

4) Duijn, C.V., 1967 : Diseases of the eye. Diseases of fishes, Iliffe book ltd., London., 309.

5) 松里壽彦・上松和夫・田代文男，1975：養殖アマゴの白内障—Ⅰ，発生状況および症状について，「魚病研究」投稿中。

6) 田代文男・熊崎隆夫，1974：アマゴに発生した白内障について，岐阜県水産試験場研究報告 №19，77～81

7) Rochon-Duvigneaud, A., 1943 : L'œil des téléostéens. Les yeux et la vision des vértébrés., Libraires de L' Académie de Médecine. Paris., 650.

8) WALLS, G.L., 1946 : The vertebrate eye and its adaptive radiation. Hafner., 785.

9) MCLAREN, B.A., E.KELLER, D.J. O'DONNELL and C.A. ELVEHJEN, 1947 ; The nutrition of rainbow trout-I. Studies of vitamin requirements. Arch. Biochem., 15, 169-175.

10) HALVER, J.E., 1957 : Nutrition of salmonoid fish.es-III. Water-soluble vitamin requirements., J.Nut., 62, 225-242.

11) COATES, J.A. and J.H. HALVER, 1958 : Water soluble vitamin requirements of siver salmon (*O.kisutch*)., U.S. Fish and wildlife service special scientific report., Fisheries, No. 281.

12) 佐藤勉・堀内三津幸・中山寛・湯川武仁・庄司圭吾・保科利一, 1975：養殖魚類の 白内障に関する研究一Ⅰ, 複世代吸虫類 *Diplostomum* sp. による白内障について, 昭和50年度日本水産学会春季大会講演要旨No.304, 54.

13) SALLMANN, L.V., J.E. HALVER, E. COLLIS and P. GRIMES, 1966 : Thioacetamide-induced cataract with invasive proliferation of the lens epithelium in rainbow trout. Cancer. Res., 26 (1). 1819-1825.

14) 宮地徹, 1966：臨床組織病理学, 杏林書院, 東京, 841.

15) DUKE-ELDER, S 1969 : System of ophthalmology-XI., Henry Kimpton, London, 777.

16) RAFFERTY, N.S., 1963 : Studies of an injury-induced growth in the frog lens. Anat. Rec., 146, 299-311.

17) YOKOTE, M., 1973 : Retinal and renal microangiopathy in carp with spontaneous diabetes mellitus. Early diabetes., advances in metabolic disorders, supl. 2., Academic Press, New York and London., 299-309.

18) 横手元義, 1975：私信。

19) 岩田修造, 1972：水晶体の白濁機構—最近の研究の中から—, 化学の領域, 26 (11), 908—917.

Explanation of plates

Pl. I

Fig. 1. Edematous changes of substania propria corneae. H.–E. stain. X 300. (Scale unit : μ)

Fig. 2. Variable changes of stroma irides (some round lymphocyte like cells migrate in the area of humor). H.–E. stain. X 40.

Fig. 3. Duplication of and concentration of corpus vitreum. H.–E. stain. X 60.

Fig. 4. Abnormal micro–fiber of corpus vitreum. H.–E. stain. X 1500.

Fig. 5–a. Swelling and edematous changes of fibrae lentis of cortex. H.–E. stain. X 300.

5–b. Initial stage of disintegration of fibrae lentis. H.–E. stain. X 400.

Fig. 6. Vacuolation and liquefaction of cortex (epitherial cells changed abnormally). H.–E. stain. X 600.

Fig. 7. Disintegration of cortex lentis. (nucleus of lentis removed to the front of the lens). H.–E. stain. X 40.

Fig. 8. Detail of Figure 7 showing the disintegrating process. H.–E. stain. X 600.

Pl. II

Fig. 9. Swelling and liquefing process of fibrae lentis (each spaces had a numerous eosinophilic particles). H.–E. stain. X 600.

Fig. 10. Reticulate construction of fibrea lentis of the advanced stage of disintegration. H.–E. stain. X 150.

Fig. 11. Abnormal arrangement of the elongated fiber-cells at the posterior part of lens. H.–E. stain. X 150.

Fig. 12. The initial stage of changing of epithelium cells. H.–E. stain. X 300.

Fig. 13. Duplicating of epithelium. H.–E. stain. X 1500.

Fig. 14. The initial stage of multilayering of epithelium. H.–E. stain. X 600.

Fig. 15. Multiplicatin of epithelium extended over large areas of lens. H.–E. Stain. X 60.

Fig. 16. Invading epithelium cell–mass (capsula lentis shrunk). H.–E. stain. X150.

Pl. III

Fig. 17. The migrating epithelial cell mass. H.–E. stain. X 150.

Fig. 18. Epithelial plugs of the posterior part of lens (nucleus lentis removed). H.–E. stain. X 60.

Fig. 19. Proliferation cells enveloped the entire lens. H.–E. stain. X 60.

Fig. 20. Proliferation cell mass included large round cells and triangular shape cells. H.–E. stain. X 60.

Fig. 21. The large cells with large and multiformed nuclei. H.–E. stain. X 1500.

Fig. 22. Variable shapes of deformed epithelial cells. H.–E. stain. X 1500.

Fig. 23. A large cell included some structure. H.–E. stain. X 1500.

Fig. 24. Mitosis of a large cell. H.–E. stain. X 1500.

Pl. IV

Fig. 25. A large cell had the cell membrane were not clearly. H.–E. stain. X 1500.

Fig. 26. A large cell with a large nucleus included many nucleolar. H.–E. stain. X 1500.

Fig. 27. A large cell with multiformed nucleus. H.–E. stain. X 1500.

Fig. 28. Corps rond and Darier's cell-like large cells. H.–E. stain. X 1500.

Fig. 29. The fibers of cortex arranged in concentric fiber–mass. H.–E. stain. X 60.

Fig. 30. The initial stage of arrangement in concentric cell mass. H.–E. stain. X 300.

Fig. 31. Degenerative change of the cell mass. H.–E. stain. X 300.

Fig. 32. Epithelial cells arranged in concentric layers within the proliferating mass (it resemebled, epithelial pearl). H.–E. stain. X 300.

PLATE 1

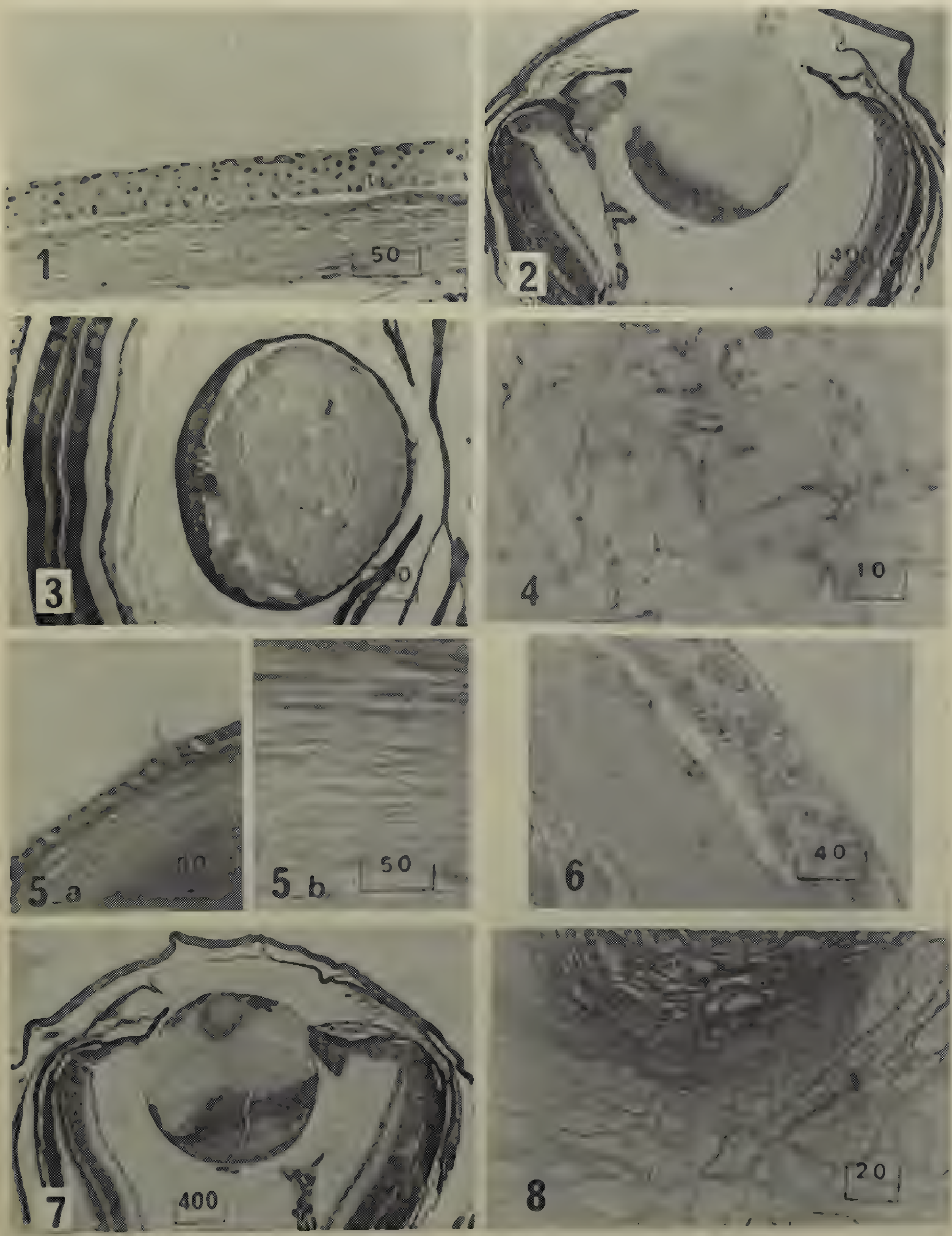


PLATE Ⅱ

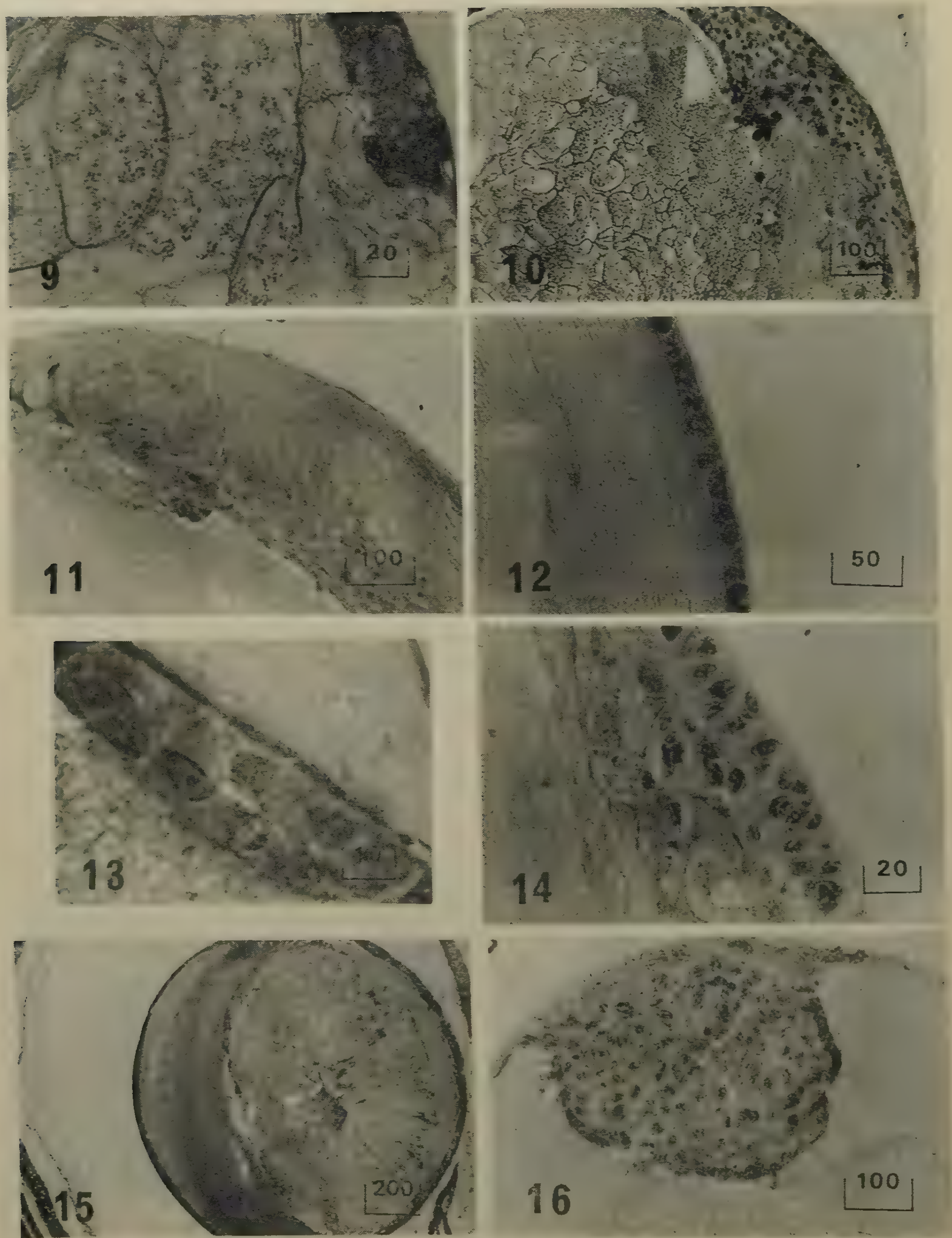


PLATE Ⅲ

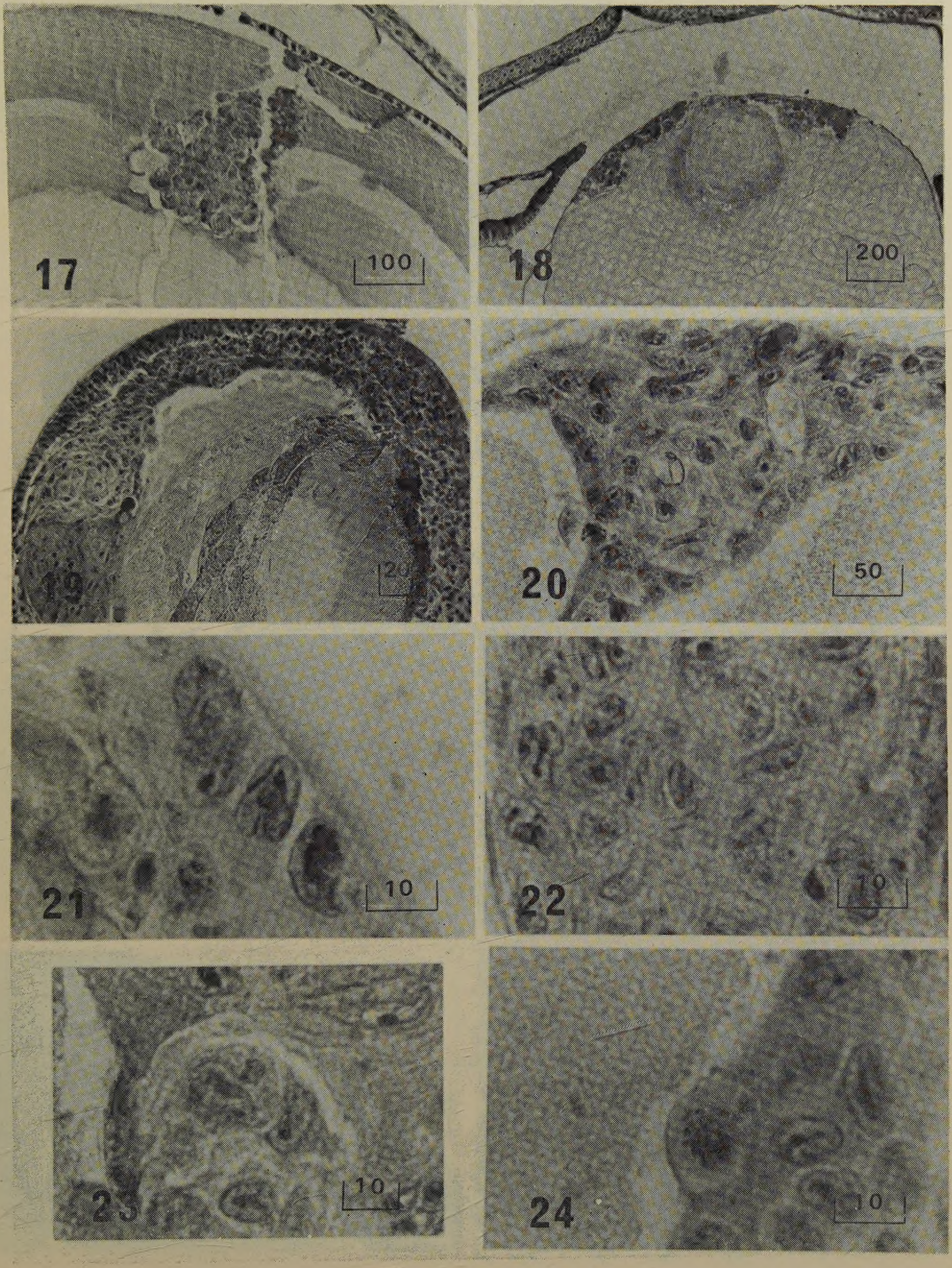
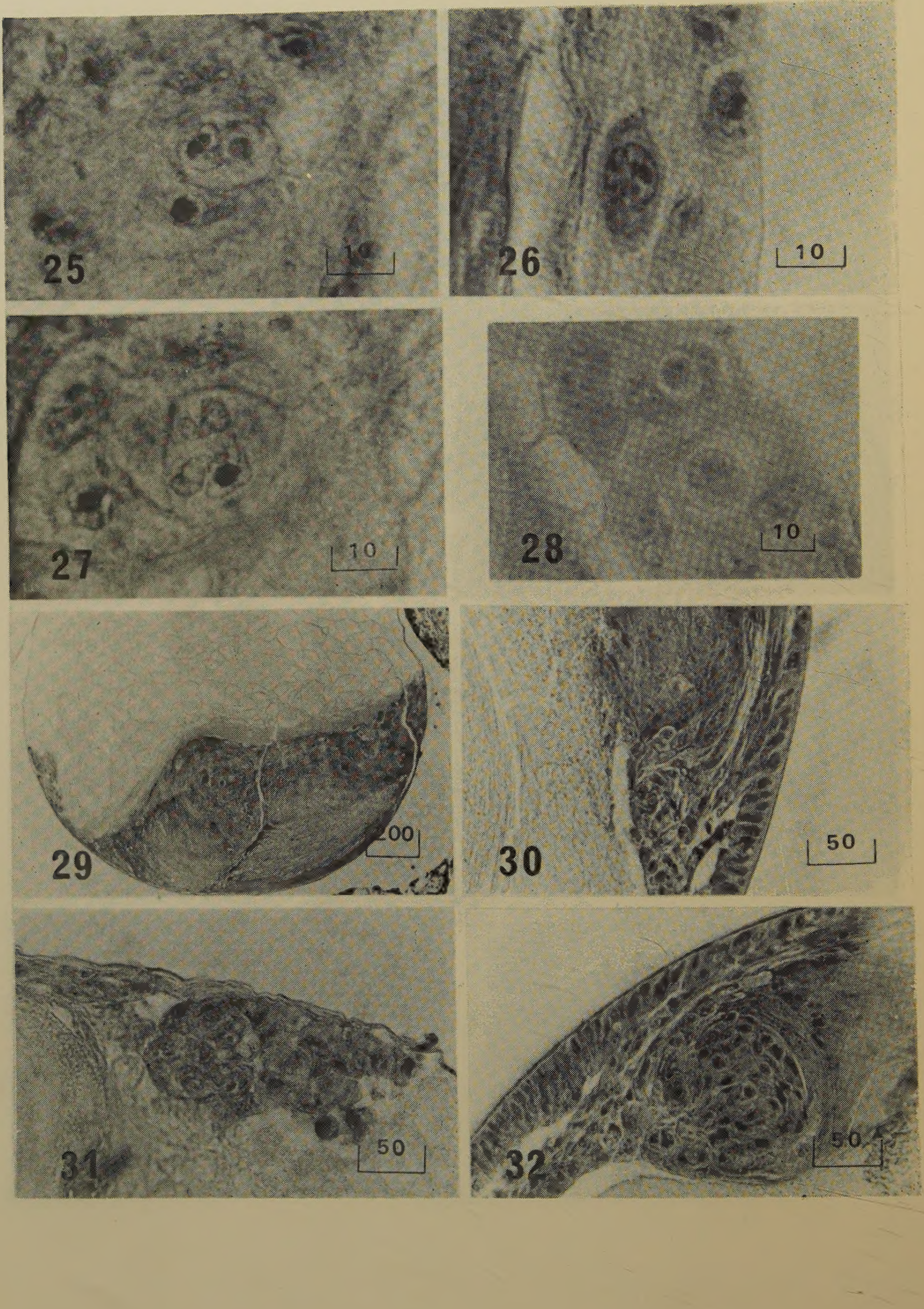


PLATE Ⅳ



BULLETIN OF THE NANSEI REGIONAL FISHERIES RESEARCH LABORATORY

is issued each year with one or two Numbers. All communications relating to this Journal should be addressed to Director.

Exchange of publication will be highly appreciated.

Address

The Nansei Regional Fisheries Research Laboratory

Director & Administrative Sections
Inland Sea Fisheries Resources Research Division
Aquiculture Research Divison
7782-9 Maruishi, Ōno-machi, Saiki-gun,
Hiroshima Pref., 739-04, Japan

Offshore Fisheries Resources Research Division
Oceanographic Research Division
6-1-21 Sanbashi-dori, Kochi, 780, Japan

〔非売品〕

昭和50年10月25日 印 刷　　昭和50年10月30日 発 行

広島県佐伯郡大野町丸石7782―9

発行者　南 西 海 区 水 産 研 究 所
花 村 宣 彦

印刷所　株式会社 中本本店印刷

CONTENTS